THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

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PERIODICAL DIVISION

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
VOL. IX, NO. 5 OCTOBER, 1928

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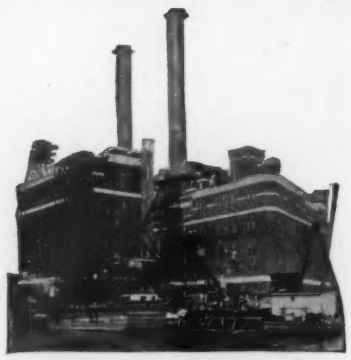

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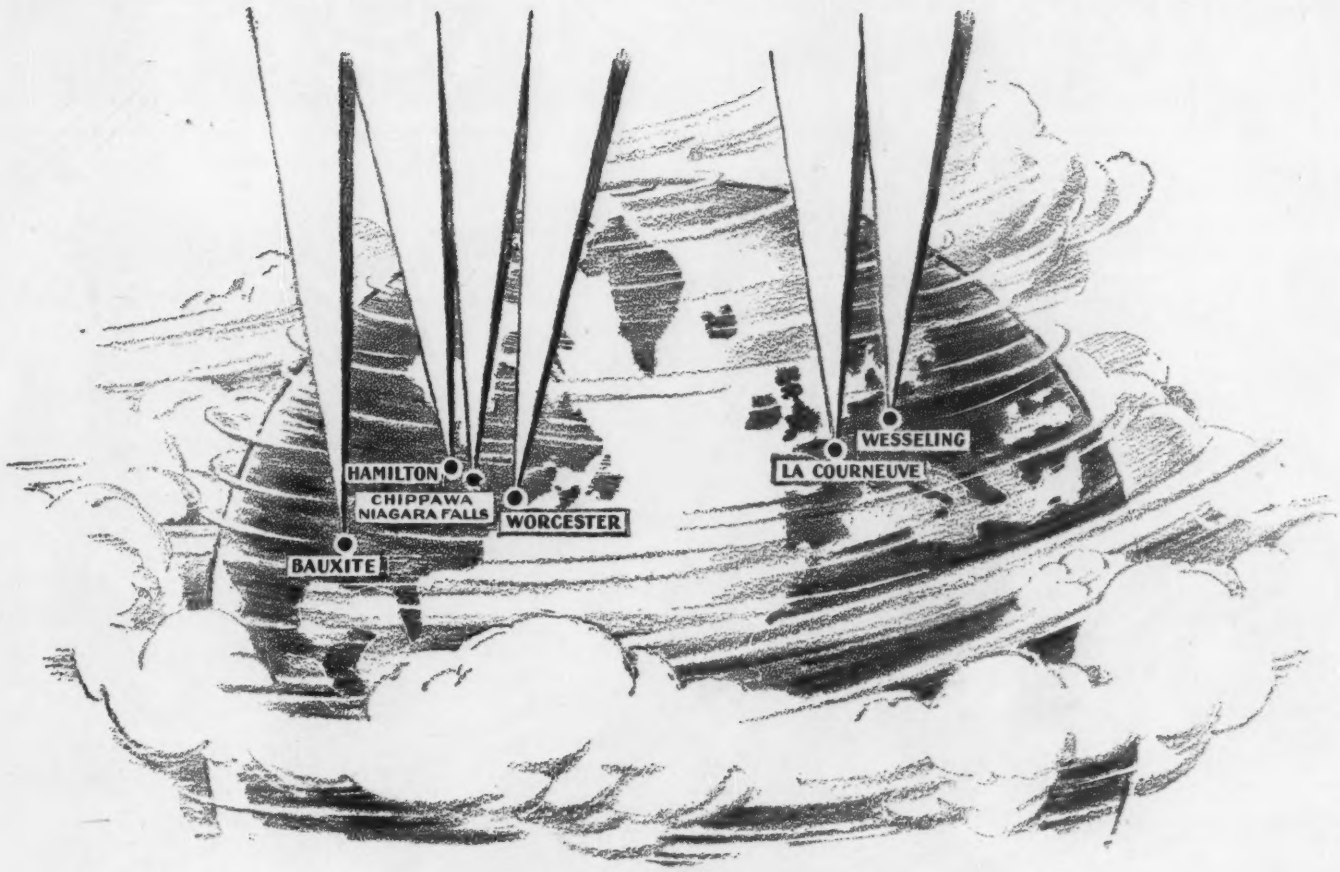

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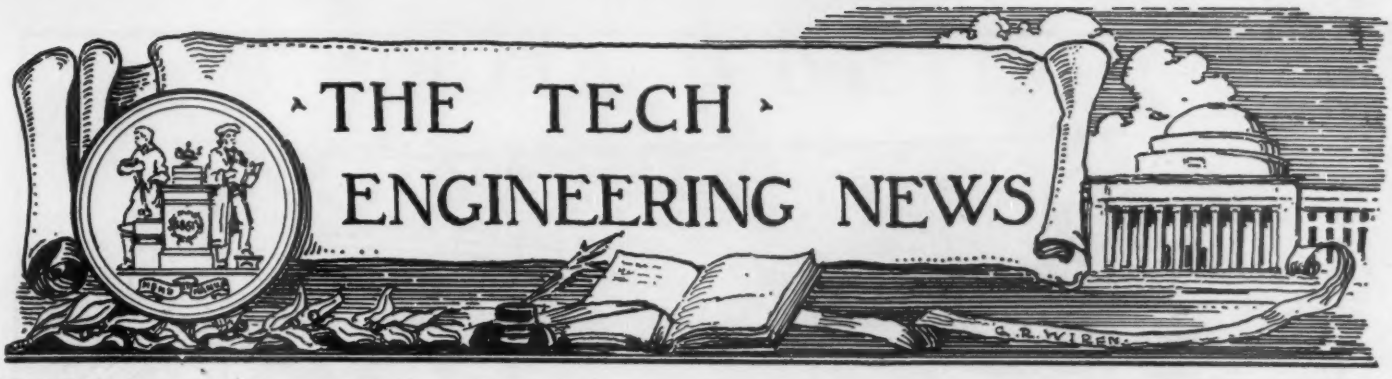

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Number 5

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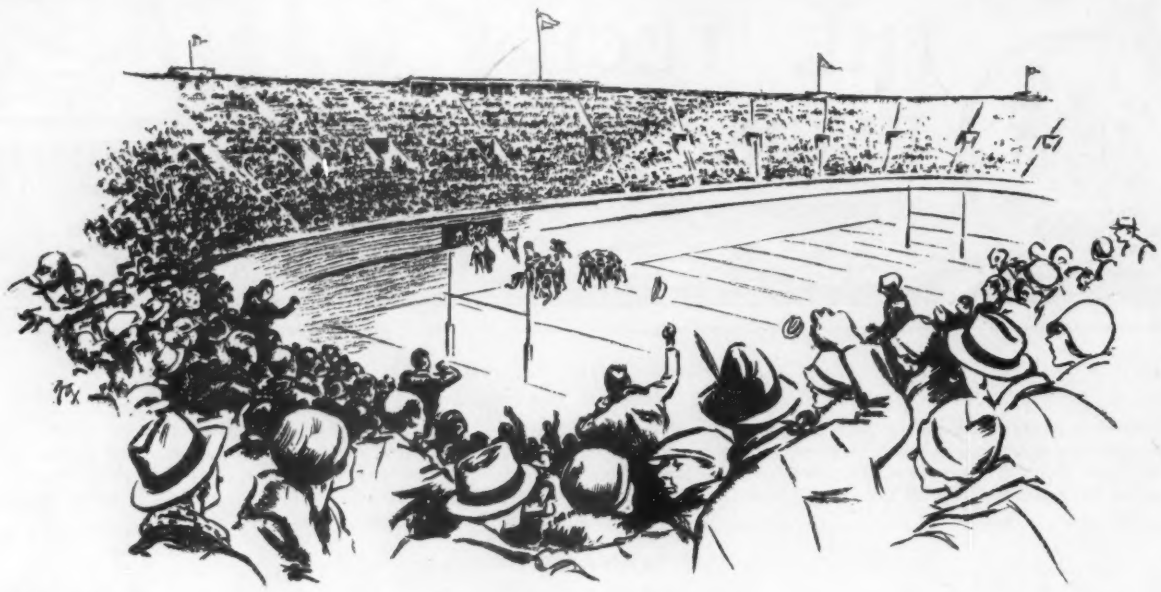

After the cheering

THE great stadium seems a living thing, swaying, swinging, moving with each play on the field. When the last fan has gone and there remains only crumpled programs and bits of torn tickets, the stadium takes on another aspect—cold, strong, gigantic, its empty seats rising row upon row.

Have you ever stopped to consider what it means to build a stadium? More than concrete, more than steel and cement go into it. Knowledge of climatic conditions, drainage conditions, subsoil. Knowledge of engineering and construction. For the stadium must be as permanent as a power plant or dam.

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME IX — OCTOBER, 1928 — NUMBER 5

Education and the Choice of a Profession

An analysis of the major qualities which indicate fitness for a given type of work

By F. ALEXANDER MAGOUN '18
Department of Naval Architecture and Marine Engineering
Massachusetts Institute of Technology

OF all the problems which inflict themselves upon the growing youth, few bear down so heavily as that inescapable question "what shall I do for a living?" The better a young man's education, the more difficult the problem often becomes, not only because of its postponement and the widened opportunities which are a corollary to education, but also because necessity and propinquity often settle the question for the less fortunate boy without regard either for his tastes or his aptitudes.

To every young man the choice of an occupation seems, and is, serious business. It would be even more so than he realizes were it not for the fact that his choice is by no means necessarily final. The president of one of our large universities recently said that no college man has a right to decide what to do with his life until he is at least a senior, and it is hard for many candidates for the degree of bachelor of arts to decide even then. Some of them never make any careful decision at all. They accept the opportunity which will pay them the most at the start, with never a thought for the morrow.

To many people the problem of the student of engineering is a much simpler one than that confronting his brother with the classical education. In reality it is no different, if indeed it is as simple, for these would-be-scientific men are called upon to elect some special branch of engineering very early in their course of study. To change from one course to another sometimes means an additional year's work, although this penalty is probably much less severe than would be that following the neglect of making an intelligent change.

The necessity of selecting a profession comes to us as engineering students earlier perhaps than any other students. The abundance of knowledge it is ours to assimilate in any one branch of science forces us to specialize before our education has fairly commenced. In the worry of selecting a suitable course, we are apt to overlook the more fundamental question of whether or not we are fitted to be executive or worker, salesman or research expert. Mr. Magoun, who is a graduate of this institution, and is at present attached to its instructing staff, has discussed this situation, offering sound advice to every student concerned with choosing a life work and obtaining a position suitable to his talents.

The problem of the young man who sought advice from a teacher of some experience is fairly typical. "You know, Professor," he said, "I've had my degree now for two whole weeks and I'm supposed to be educated, but I don't even know enough to be able to decide what to do next year. My father wants me to be a lawyer and he says he'll send me to the law school providing that I'll go in the fall. My uncle offers me a good place in his business with the same stipulation. Now what am I going to do? Be a lawyer, or a business man?"

"You have two choices and two perfectly good alternatives," the professor replied. "Suppose you try the law and discover that you prefer business. You'll be a much better business man for knowing some law. On the other hand suppose you enter your uncle's employ and discover that your heart is really in the legal profession. You'll be a better lawyer for your business experience. There are other business opportunities beside the one your relative offers to you, and others ways of paying the cost of post graduate education beside allowing your father to defray it. The important thing is for you to find out what you really want to do and then to do it. After all, no worth while effort is ever lost. My advice to you is that you go home, get a good night's sleep, and follow whichever course appeals to you most tomorrow morning, knowing that the choice has none of the unfortunate finality which makes it seem so stupendous to you."

The soundness of this advice is well demonstrated by the career of a neighbor of mine. To please his mother, he entered the United States Naval Academy at Annapolis where, in spite of the intense competition, he stood among the six brightest men of his class. But he did not want to be a naval officer. Then, to please his father he undertook a course of study in the Harvard Law School with similar scholastic success and similar yearnings for something else.

Ultimately he left the law school. He bought a second-hand kettle and an old stove which he set up in a small room usually occupied by students. When the first batch of fudge was poured onto a wooden table of his own

(*Continued on page 228*)

Capacity to Apply

The function of The Engineering Foundation in making the achievements of science available for human welfare

By ALFRED D. FLINN
Director, The Engineering Foundation

CAPACITY to apply has created civilization. Men who applied themselves to chosen enterprises have in their several ways, through the centuries, persistently increased the human stores of goods and of knowledge, and have progressively applied also both materials and knowledge to benefit mankind. Others have generalized the products of observation into laws or theories, aiding both those who discover and those who utilize. Arthur D.Little, '85, has suggested that "those having the simplicity to wonder, the ability to question, the power to generalize, the capacity to apply" constitute the "Fifth Estate" of the realm. Prof. Henry M. Le Chatelier, of the University of Paris, in a recent paper concludes "that the formation of an intellectual élite entails the union of four qualities — industry, imagination, judgment, training." Many engineers are to be found in the Fifth Estate, eminent for capacity to apply. Those having capacity to apply are enabled to do greater things by increase of the store of facts about Nature. Forces must be revealed and understood, and the characteristics of substances under various conditions must be determined, before they can be utilized. Systematic pursuit of new knowledge is, therefore, also essential to civilization.

New discoveries of facts and principles enable men to make further applications of facts and principles previously known as well as of those newly discovered. By these reciprocal, step-by-step advances of the arts and sciences more than one new industry has been based on knowledge long possessed but utilizable at first only to a limited degree. Those who have the capacity to apply owe to the world the completest practicable utilization of knowledge of forces, substances and life, including man. Those who profit by these labors and amass wealth through capacity to accumulate likewise have an obligation — to devote some reasonable portion of their fortunes, seedlike, to the furtherance of research for both fundamental knowledge and its application.

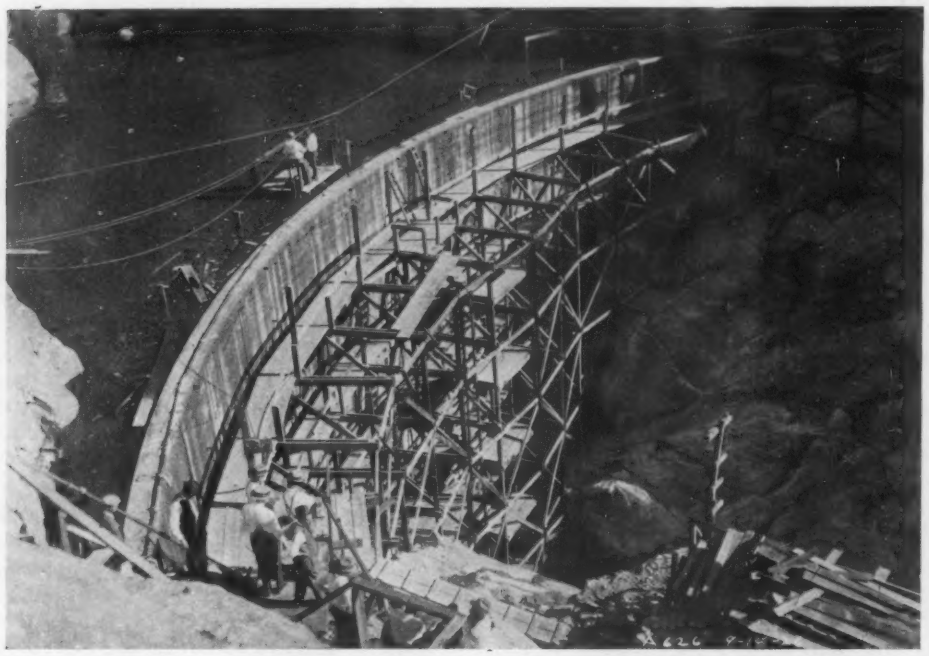
Application requires its own especial stores of facts about means, methods, tolerances, limitations, economic values, desirability, social results, political effects. The world needs much study of application, and much is being done. Robert A. Millikan reminds us that two centuries elapsed before the great discovery of Newton found any particular application; yet without it modern progress could not have started. Discoveries of present-day physicists, chemists, mathematicians, biologists, astronomers, geologists, psychologists, suffer no such delays, if made known so as to be understood.

Fifteen years ago, Ambrose Swasey, eminent engineer, collaborator with scientists, designer and manufacturer of instruments and machines of precision, builder of great telescopes, proposed to the four senior engineering societies of the United States an aid to engineers in solving problems requiring new knowledge, or new means or methods for application of facts or principles already known. These societies of civil, mining, mechanical and electrical engineers established Engineering Foundation, in 1914, "for the furtherance of research in science and in engineering, or for the advancement in any other manner of the profession of engineering and the good of mankind." To this foundation Mr. Swasey gave the beginning of its endowment. Others who get his vision of its possibilities are adding to this "community trust," delimited by fellowship of interest instead of geographical boundaries.

In April, 1915, Engineering Foundation Board first met. Europe was at war. To many it appeared inevitable that the United States would be involved. Scientists and engineers organized for anticipated demands upon their capacities to discover and to apply.

Engineering Foundation's first notable service was to aid the National Academy of Sciences to establish the National Research Council, in 1916. There followed years given mostly to war and reconstruction coöperation. Not until 1923 did the Foundation fully return to its intent to aid the engineering societies in useful investigations of problems of general interest to the profession, the industries, public works and public utilities, not likely to be undertaken by other bodies. The Foundation has assisted committees in studies of concrete arches and of steel columns for building and bridges, of mining methods, of the properties of steam, of lubrication, of phenomena connected with electrical insulation, and a number of other subjects. It has organized and aided in financing and directing large coöperative projects; brief mention will indicate possibilities.

Investigation of "fatigue" (or endurance) of metals was undertaken at the University of Illinois, in association with National Research Council and industrial corporations. This enterprise inspired notable parallel investigations by a number of workers, in several laboratories. The total contribution to knowledge of the subject has been of major importance.

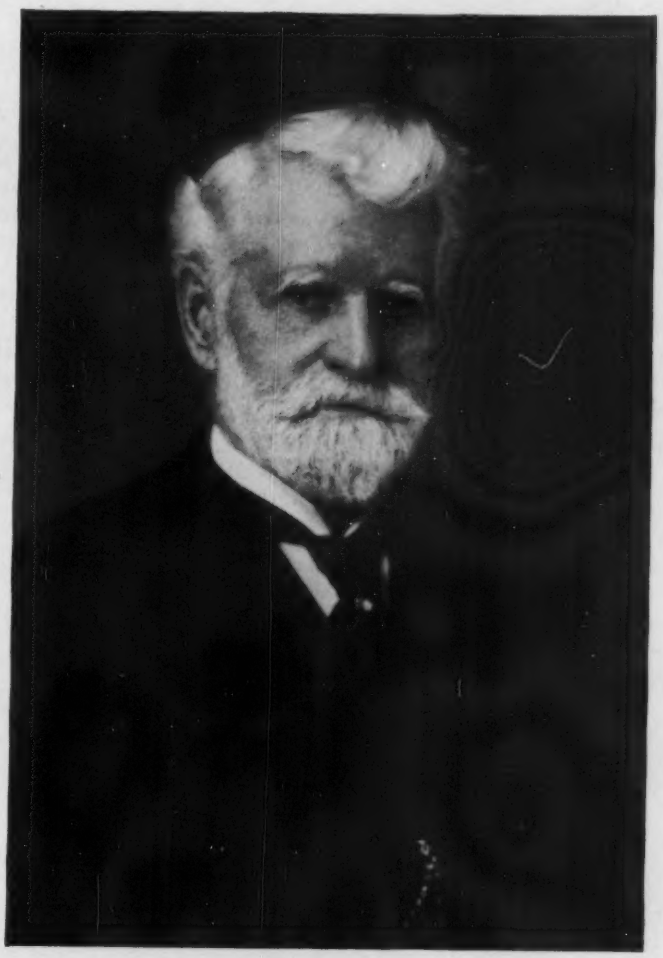


EXPERIMENTAL DAM CONSTRUCTED BY ENGINEERING FOUNDATION

With the coöperation of American Society of Civil Engineers, National Bureau of Standards, Bureau of Reclamation, several universities, some three score utility, manufacturing and banking concerns, and a large number of American and foreign engineers, the Foundation is carrying on an investigation, begun in 1923, of arch dams for power development, irrigation, water supply and flood control. Measurements on old and new dams, tests on an experimental dam one hundred forty feet long, sixty feet high, equipped with scores of special instruments, and laboratory tests on models of celluloid and of concrete, are parts of this investigation. (See THE TECH ENGINEERING NEWS for December, 1926, page 277.)

Iron blast furnace slags research is another experimental study of immediate usefulness. The Foundation coöperated with National Research Council in establishing the Personal Research Federation, devoted to scientific study of man in relation to his occupations, and his education therefor, the Highway Research Board, the National Bureau of Welding, and in other undertakings. It coöperated with the Society for Promotion of Engineering Education in its helpful studies now progressing. The projects aided—by Engineering Foundation have been well distributed over the country. Through its "Research Narratives" and other dignified publicity it has done much to spread intelligent appreciation of engineering among the public. Assistance for competent inventors and for researchers having ideas that may develop merchantable inventions has been considered repeatedly, but no satisfactory procedures for dealing with patents and other business features have yet been formulated. Recent suggestions raised hopes for finding a way to perform this service.

A comprehensive Alloys of Iron Research has been developing for the past year and a half by the collaboration of American Institute of Mining and Metallurgical Engineers and Engineering Foundation with the industries, several universities, Bureau of Standards, Bureau of Mines, and technical societies. Man has used iron for more centuries than archeologists yet can tell, but scientifically accurate knowledge of iron and of its combinations with other elements is meager. Relatively few persons have seen *pure* iron nor is it being produced in large quantities or at a price that would encourage extensive use. Absolute purity of anything is unattainable, but the approximations now achieved with extreme care, for iron and some of the substances which combine with it, are so close to purity that researches by which fundamental knowledge can be increased are becoming feasible. So great are the benefits for every industry that the search after fundamental knowledge, both that scattered through a voluminous, chaotic literature and that to be discovered by experiments conducted with the best methods of science, in laboratory and plant, is justified. Good work is being done in this and other countries, but rich rewards await a concerted, well organized and well supported search.



DR. AMBROSE SWASEY
The Founder of the Engineering Foundation

Plans for the immediate future embrace continuation of investigations, of which examples have been given, development of others, of which the societies have a number, of prime importance, awaiting funds, activities for informing the public reliably about the numerous contributions of engineering to the modern betterment of living, and aid to engineers in solving their "human problems."

Present day facilities for communication, transportation, sustenance, mass production, diffusion of knowledge, research — created largely by engineering capacity to apply the discoveries of science — are shaking many a tradition. They force questioning of old practices of commerce; of distribution of the increments of wealth by means of profits on sales; of mechanisms of government devised under the conditions of past centuries; of methods of living, working and teaching elaborated before the invention of modern equipment; of prohibitions as means for control of human conduct.

Engineers perforce have a new language and strange uses of old words; they have created new conceptions as well as new mechanisms; they are not understood. They must expedite the spread of the new knowledge among their fellowmen. A new leadership in the affairs of the world has come to engineers as an obligation, following unprecedented achievements in the application of natural forces to the advancement of the whole race of men.

Have engineers been Dan Phaethons? "Once upon a time" this ambitious young son of the Sun attempted to drive his father's chariot across the sky, but was unable to keep the steeds in hand. He got so far off route that parts of the Earth were scorched. The car of life and blessing, lacking guidance, did great damage. Engineers by their applications of physical forces to useful services have brought uncounted benefits; but, having harnessed these steeds, have they helped to drive them safely? Have engineers sufficiently concerned themselves with the economic, sociological, political, moral and religious effects of the exercise of their capacity to apply?

Lawyers, statesmen, politicians, preachers, teachers, poets and painters cannot rapidly enough slough traditions, assimilate the new knowledge, and interpret it to the multitudes. Engineers must share leadership toward a new statesmanship, a new philosophy of life, a new economics with a cheerful outlook, fine arts inspired by man's growing dominion over his surroundings, a new understanding of human forces and their direction. Frequently engineers' decisions fundamentally affect the economics of industry, of commerce, of public utilities, of public works, in ways not always comprehended. Engineers should sit with authority, not merely as advisers, in

(*Continued on page 214*)

The Neon-Electric Stroboscope

Formerly a scientific toy, it is now an essential in measuring rotational speed of electric apparatus

By DANIEL O. WOODBURY '21
Engineer, General Electric Company

EVERY laboratory worker is familiar with the stroboscope, or synchronous speed indicator, with which it is possible to observe changes in the rotational speed of electric machines, or, with the aid of a special tachometer, to take readings of shaft speed without actual mechanical connection with the machine.

The word stroboscope is taken from the Greek, and means "whirling mark." In its simplest form, the device consists of a disk attached to the shaft of an alternating-current machine under test, and laid off in alternate black and white sectors, the number of which is equal to twice the number of poles of the machine. When viewed directly by the eye, the revolving disk appears as a blur. However, if some means is provided so that the eye sees the disk only instantaneously, an equal number of times during each revolution, the sectors will become visible, and will appear to rotate one way or the other or to stand still, depending upon whether the viewing arrangement is in step with the motor, or is faster or slower.

A common method of viewing the stroboscopic disk is by means of a carbon arc lamp, supplied with alternating current from the same source as that which is driving the motor under test. Although the light of the arc appears to the eye to be continuous, its brilliancy varies greatly during the voltage cycle, so that it may be used to provide the synchronous flashes which give the disk its stationary appearance.

The success of the stroboscope depends upon the ability of the eye to retain an image after the object which causes it has been taken away — an effect called persistence of vision. If the object is revolving, and is viewed instantaneously in the same position more than sixteen times per second, persistence of vision leads the eye to believe that the object is standing still. The same effect is attained by the stroboscopic disk if the sectors are exactly alike in size and angle, and if the frequency with which they are illuminated is an even multiple of the rate of the disk's rotation. If the speed of revolution is somewhat out of synchronism with the flashes of the lamp, the sectors appear to revolve either forward or backward. The speed of this apparent revolution is equal to the difference between the frequency of the flashes and the speed of the disk.

FIG. 2
Wave shape for which the neon tube is designed to operate in the new stroboscope

In the tachometer device, the arc lamp is replaced by a steady source of illumination such as daylight, and the stroboscopic disk is viewed through a narrow slit cut in a second disk. The latter is attached to the shaft of a hand-operated tachometer, and when the observer has brought the instrument up to the speed at which the sectors on the stroboscope disk appear to stand still, he reads the revolutions directly upon the tachometer dial.

While these simple stroboscopes are useful in many ways around the laboratory, they are not sufficiently accurate for use in the study of the angle of lag of synchronous machines under load. This study has lately attained considerable importance in connection with the design of large electric power networks in which the economic limit of power carrying capacity depends upon the stability of the synchronous machines under load.

About three years ago, a group of engineers of the General Electric Company undertook a study of system stability conditions, using an artificial line, an alternator and a synchronous motor. One of the important facts to be recorded in all tests was the angle of lag of the machine rotors under many different conditions of loading, switching, etc. The only available device that would give this was the oscillograph, and with that instrument the results were attainable only from computation. What was needed was a form of stroboscope which would read directly the electrical angle of lag of the machine rotors, would be accurate, and at the same time ruggedly constructed and easy to operate. The usual type of stroboscope already described could not be used, nor were there available any improvements upon it which fulfilled the requirements satisfactorily. It was therefore necessary to devise a new instrument, the neon-electric stroboscope.

The credit for the new stroboscope belongs to Mr. C. A. Nickle, of the Engineering General Department of the General Electric Company. While it was originally intended as a special test device only, it proved to be so successful that the company decided to manufacture several, with a view to finally standardizing the instrument as a regular piece of laboratory equipment.

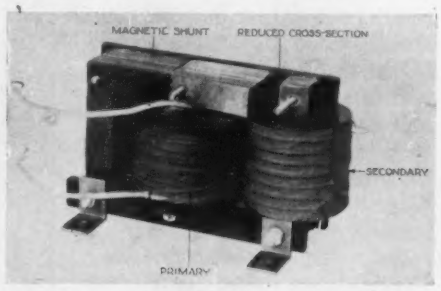


FIG. 1
Special transformer for the neon-electric stroboscope

The heart of the new stroboscope is the neon tube — a small neon-gas-filled lamp which glows with a brilliancy which is almost instantaneously responsive to the voltage impressed upon the tube terminals. The neon tube is of course a well-known device, being used in talking motion pictures, television, and radio photography. Its characteristics have been the subject of investigations which date back to Sir William Ramsay's discovery of the gas neon in 1898, and to the pioneering work of D. McFarlan Moore, who began his experiments with electrical discharges in gases in 1893. Nor is the application of neon tubes to stroboscopes wholly new, since a number of types of this instrument have been designed for special purposes, using the instantaneous characteristic of neon to obtain the flashes necessary to illuminate the disk sectors. However, all previous forms have been complicated and delicate, and have required various moving parts such as revolving disks, pulleys, electrically driven tuning forks and the like. The Nickle stroboscope,

on the other hand, contains no moving parts whatever beside the sector disk, and is compact and portable.

It consists of a special transformer and tuned circuit, a small neon lamp, and a disk for attachment to the shaft of the revolving machine.

Transformer and lamp are mounted in a small wooden carrying case, weighing perhaps 30 pounds, and the only connection required is a 110-volt line leading from the same source which supplies the test machine. The neon tube is mounted in one end of the box next a small opening which permits the light to be thrown outward. Reflecting mirrors behind the tube concentrate the light on the opening.

By means of the special exciting circuit, the tube flashes for a period estimated at about 1/50,000 of a second during each half cycle of the supply voltage, thus giving a practically instantaneous view of the stroboscopic disk, which, during that interval, revolves through an almost imperceptible angle. The disk, instead of being marked off in equal black and white sectors, is painted black all over, and carries several equally spaced radial white lines about 1/16 inch wide. The number of these lines must be an integral divisor of the number of poles on the machine to be tested, and must be great enough to give at least 20 images a second at a given position on the disk. Thus for a four-pole machine a disk with only a single line marked on it is necessary, although a complete diameter will give twice the number of images per second and hence will be easier to read.

A circular scale marked in electrical degrees, and extending over an arc equal to one pole pitch, is supported on the motor frame in such a position that the image of the white line appears as a pointer beneath it. Readings of the angular position of the rotor can then be taken directly, their accuracy having been demonstrated to be on the order of .02 inch.

While the construction and operation of the neon-electric stroboscope is exceedingly simple, the theory of its design is somewhat more involved. The difficulty lies in obtaining an exciting voltage for the neon tube, which shall have very sharp peaks of the shortest possible duration. Ordinary sine-wave voltage, while fairly adequate for the simple type of stroboscope, will not give the sharp definition of the pointer line necessary to the accurate reading of small angles. Some sort of a special circuit is required. This was finally obtained by the use of an exciting transformer having special core iron and a magnetic circuit of a limited cross-section at one point so as to obtain saturation very early in the cycle.

The voltage induced in the secondary winding of a transformer is of course proportional to the rate of change of the magnetic flux. If the transformer is excited by a sine wave voltage, the secondary voltage will also be of sine wave shape, so long as the core density remains below the knee of the saturation curve. Once the saturation point is passed, however, the flux becomes substantially constant, and the secondary voltage drops to zero. Thus if the cross section of the iron linking the secondary coil is restricted at some point, saturation can be made to occur very early in the cycle, and an approximation of a rectangular flux wave may be obtained. This results in two peaks of secondary voltage per cycle. The effect can be still further increased by the use of a special iron in which the knee of the saturation curve is well defined and abrupt.

In order to accentuate the two peaks still more, the secondary circuit containing the neon lamp was tuned with a suitable condenser. This arrangement was found to be so much of an improvement on the transformer alone, that it was adopted as standard. There was, however, one difficulty which accompanied the use of a tuned circuit, that is, the production of an oscillatory discharge possessing a group of voltage peaks, the first few of which were large enough to light the neon tube several times in succession during the half cycle. The effect on the instrument was then to produce several images of the white line on the stroboscopic disk, close enough to the principal pointer line to confuse or blur its image.

Various methods of overcoming this difficulty were adopted. First, the transformer was so designed that the neon lamp constituted a considerable load upon it. This fact makes for the suppression of the harmonic voltages in the tuned circuit, while it does not seriously cut down the first peak. Secondly, the neon tube was specially designed so as to be relatively insensitive to lower voltages. Thirdly, an adjustable magnetic shunt was provided around the secondary core iron, so that the primary load current could be adjusted with respect to the tube current. The combination of these three, together with careful proportioning of the constants of the tuned circuit, gave an entirely satisfactory result. The neon lamp flashes once with high brilliancy, and again several times so faintly as to be hardly noticeable. The second group of flashes occurs much later than the first, and is therefore in no danger of being confused with it.

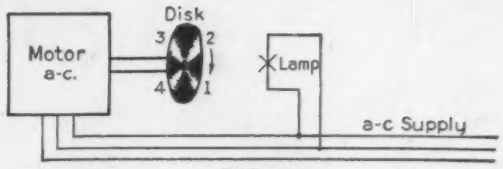


FIG. 3
Diagram of a simple form of stroboscope

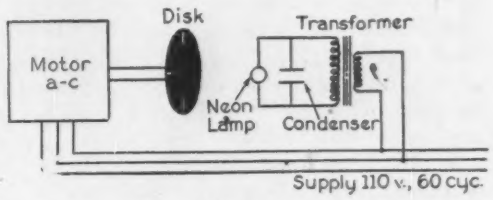
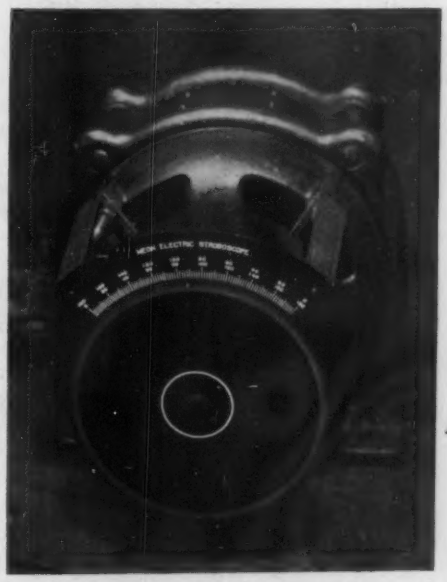


FIG. 4
Diagram of the neon-electric stroboscope

Figure 1 shows the special transformer with the constricted portion of the magnetic circuit on top. This portion is composed of a few sheets of core steel held between the ends of the remainder of the core, which is of full cross-section in order to permit as much power as possible to be transmitted from primary to secondary windings. The transformer is necessarily a compromise, since it is impossible to obtain an exact rectangular wave shape and at the same time induce sufficient current in the secondary.

The neon-electric stroboscope is an interesting example of the outgrowth of a useful principle from an investigation along an entirely different line. If we were to analyze the hundreds of essential machines and instruments which science has given us, in the past one hundred years, we would undoubtedly find that many of them, like the new stroboscope, began as unimportant side issues, and proved so suddenly and unexpectedly successful as to form the basis for whole new lines of development.



STROBOSCOPIC DISK

A white image on the disk acts as a pointer to the scale when the disk is illuminated with the neon lamp.

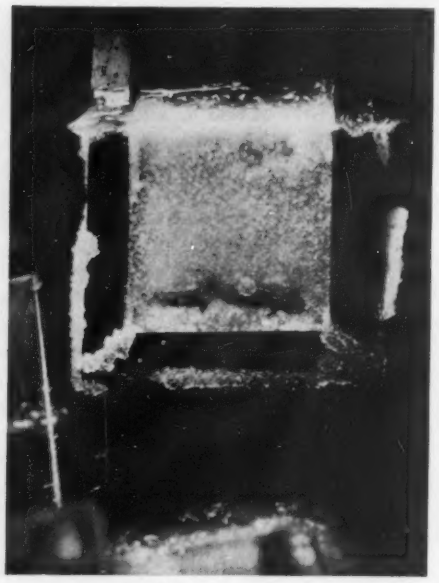
Ice Engineering

The removal of ice jams which annually threaten great loss in life and property

By HOWARD T. BARNES, F.R.S.
Professor of Physics, McGill University

IN this short paper it will be my object to give some idea of what ice engineering is, what it has done, what materials and methods it uses, and how these might be applied in a practical way. In order to be brief it will be possible to give only a very general outline of the subject.

In the first place, then, what is ice engineering, and in what sort of problem is it interested?



ANCHOR ICE
Anchor ice forms beneath the surface of the water; in the above picture, on a piece of wire screen.

It is the most recent member of the family of engineering sciences and has to do with the prevention and control of ice formation in rivers and lakes, the removal of ice jams that annually cause the shutting down of power houses, and the flooding of vast areas, with the resultant loss of life and property, the removal of frost and snow when and where desired, the assistance of winter navigation, the removal of the iceberg menace, and countless other similar topics.

The ice engineer is faced with two distinct types of problems: firstly, the prevention of economic disaster that may be caused by ice; and secondly, the relief of such distress after it has arisen, and in emergencies.

It is gradually being realized in Canada and the New England States that it is of the utmost economic interest to guard against trouble with ice before the trouble arises. For example, no dams, power houses, waterworks, or similar structures should be built without attention to the effect such constructions will have on the formation and accumulation of ice. This is particularly important in dealing with navigation problems such as the dredging of ship channels in a river and the laying out of canals and harbors.

The factors that contribute towards ice formation are the earth's radiation outwards, wind agitation, surface disturbance in rapids and waterfalls, deficient humidity, and large exposed surfaces. The greatest of these is the earth's radiation. In winter, during the night, water loses heat more rapidly by radiation than it receives solar energy during the day.

Nature's methods of preventing ice formation are solar radiation, radiant heat, reduction of exposed surface, warm rain and high humidity. It has been found that, with the exception of a few particular cases, the greatest success in prevention and destruction of ice follows the adoption of methods which are as like as possible to those adopted by nature herself.

Explosives, like dynamite, or black powder, which have in the past been resorted to only in the case of emergencies, are of comparatively little value, although in particular cases they may have a certain amount of use. The effect of an explosion is merely to deliver a short sudden blow to the ice, which blow is too rapid to more than shatter a small part of the ice just where the charge of explosive has been set off.

The most effective material for general use has been thermit, although during the past year new and even more powerful substances have been discovered.

Thermit is a mixture of iron oxide and aluminum, and one variety of this mixture is used extensively for welding. Many have seen this material in action on the city streets where rail joints of a trolley line were being welded, or in manufacturing plants. A special thermit is manufactured for ice work, of greater power, by The Metal and Thermit Corporation of New York. It is not an explosive and is perfectly safe to handle and requires very special means to be made to react. It will pass through any ordinary fire intact. In fact warehouses containing thermit have been known to burn down and after the fire was over the thermit was swept up and used in its original condition.

By special means thermit can be made to ignite by being raised to a sufficiently high temperature for the reaction to start between the aluminum and the oxide of iron. This reaction consists in the changing of aluminum to aluminum oxide, liberating iron and the heat formation of the metallic aluminum. So rapid is this change and so great is the heat given out that in the first few seconds the temperature of the mass is increased until it is about one-half as hot as the sun. In this condition the iron is in the state of a white hot liquid and the radiation from the molten mass contains rays that equal or surpass those of the sun in power to penetrate ice for many feet. In this way thermit is the nearest approximation to the sun itself that we can so far obtain on earth.

The experiments of thermit were first conceived as a result of a double study of icebergs and sunrises. It was observed that just at dawn the most cracking and disintegration of icebergs takes place. During the night, the surface of the iceberg freezes over. In this way the first rays of the sun which contain a very large proportion of ultra-violet radiation can penetrate deep

PACK ICE
Pack ice forms on surface, blocking navigation

into the ice. This sets up unequal strains throughout the mass. During the day, however, the iceberg is covered with a film of running water which absorbs most of the sun's rays and prevents them penetrating into the iceberg itself.

Observations such as these led to a consideration of means for putting the

sun inside the ice where it would be more efficient, and it has already been pointed out that the nearest approach to the sun itself is thermit.

Thermit has another advantage besides its short wave radiation. Shortly after the reaction is started the mass of thermit soon reaches a temperature of enormous magnitude. This temperature, contained in the molten iron, causes the ice to split into its constituent parts, hydrogen and oxygen, with explosive violence. The oxygen is mostly fixed by the iron to form iron oxide again, while the hydrogen is liberated as a very hot penetrating gas which burns in the presence of air in the top of the ice in a sheet of flame.

CHANNEL OPENED BY CALCIUM CHLORIDE

Cutting a channel through surface ice for ferry service by calcium chloride

To the casual observer the result of a thermit reaction in ice is to cause the material to be classed as an explosive. When set off in ice it causes the ice itself to explode. Hence it is not the thermit reaction but the ice itself which becomes the explosive, the heat of the thermit being the means for setting it off. The ice explosion is much slower than dynamite and acts as a great heave to the ice instead of a sudden blow. Consequently it helps greatly to crack and break up great masses of ice, as those present in jams and icebergs.

In addition to this disruption by the explosion, the water currents are restored to their original channels and continue to wash away the ice weakened by the heat rays and the explosion. In this way a huge jam may be broken up so that it will float piecemeal harmlessly down the river and an iceberg split into fragments so small as to be no menace to commerce.

In February, 1925, for the first time, an iceberg was treated by this radiation heat method. On that occasion two hundred and fifty thousand tons of ice, near Waddington, N. Y. in the St. Lawrence River, were moved out in a few hours, after the reaction of three thermit charges of ninety pounds each.

An ice jam, below Ogdensburg, N. Y. at Chimney Island, was moved in nine hours by placing two ninety-pound charges of thermit at the key point. An estimate of the amount of ice moved by this small amount of material was one million tons.

A small jam was lifted off a shoal at Clark Island, on the St. Lawrence River, and broken up by one charge. Many other operations have been successfully carried out, including the removal, without damage, in ten days, of a dry dam twenty-five miles long at Oil City and Franklin, Pa. The city of Belleville, Ontario, on the Moira River, was protected from flood last winter by the thermit treatment.

Flood conditions along the St. Maurice River, at LaTuque, Quebec, have been prevented successfully during the past winter by using about a ton of thermit, placed throughout the jam at intervals of six hundred feet or more.

But thermit is by no means the only method of fighting ice. Chemicals such as common salt and calcium chloride have a powerful influence in destroying and rotting hard solid surface ice. Calcium chloride in particular is exceedingly useful for establishing lines of weakness across a layer of surface ice so that it offers no resistance to an ice shove or to the heave from the thermit treatment. Young ice can be destroyed in a few hours and channels kept open with these substances. Calcium carbide also has its uses and appears to possess a powerful rotting action on ice accumulations.

It is well established, however, that the most economical method of handling ice situations, where possible, is the use of ice breaking ships. For opening ship channels through ice and for keeping such channels navigable there is no method so quick and economical as this. There are places, however, where ice breakers cannot work, and it is to these inaccessible places that the chemical treatments as outlined by the new methods of ice destruction are economically feasible.

PLACING A THERMIT CHARGE

Maj. H. B. Faber assisting in firing the first ninety pound thermit container

In certain places in Canada small tugs have been employed to steam up and down power canals and thus keep surface ice from forming and blocking them.

Pyrotechnical torches that will burn under water, mercury vapor lamps with special rays, and other more specialized devices may be employed in particular cases to good advantage.

The main object of all ice prevention methods is to destroy the ice forming power of the water. It is not generally known, but has been established recently, through special experiments,

(*Continued on page 222*)

DESTROYING ICE WITH THERMIT

Disintegration of a solid block of ice two foot cube by the heat from two and one-half pounds of thermit

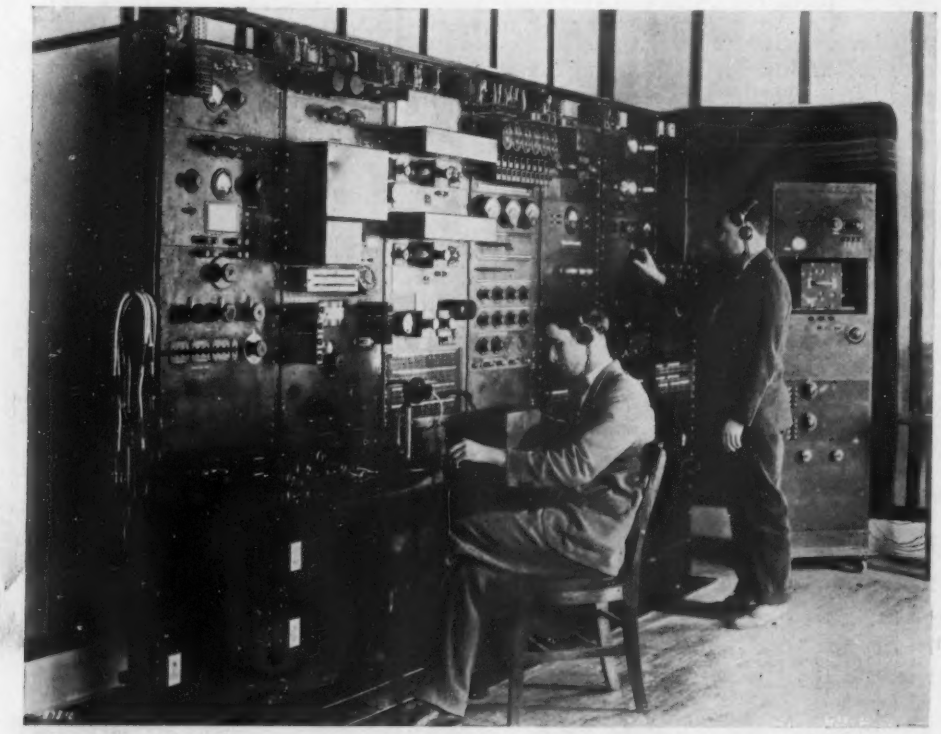
Transatlantic Radio Telephony

A summary of the problems involved in the field of transoceanic communication

By Dr. J. O. Perrine
American Telephone and Telegraph Company

In the field of electrical communications, transatlantic telephony is a notable step in the march of progress. Commercial transatlantic service was opened in January, 1927, and since that time has daily carried the human voice across the broad expanse of water, separating the Old and New Worlds. Playing its role as an adjunct to great networks of wire lines in the United States and Europe, the transatlantic radio link joins 80 per cent of the world's 30,000,000 telephones in one great network.

Transatlantic telephony is a fascinating subject with many ramifications. It possesses a wide variety of interesting qualitative and quantitative problems, of which some are purely scientific while others have a business, operational, traffic, engineering or economic character. Any one of these would be an appropriate subject for an article in The Tech Engineering News. The particular theme chosen is one of distinctive engineering character, namely, the quantitative measurement side of radio telephony as it contributes to more effective utilization of transmitter power and received signal.



TRANSATLANTIC RADIO RECEIVER AT HOULTON, ME.
Double detection apparatus and oscillator on the right, testboard for wire lines on the left

Someone has said: "Until you can measure, you do not know." This is a terse way of stating that qualitative information is not sufficient. To be made completely serviceable to man, Nature's phenomena must be studied quantitatively. It is the business of the engineer to measure and to know quantitatively, and moreover to know quantitatively from the economic standpoint. To no branch of engineering or specific problem in engineering does this philosophy apply more potently than to transatlantic radio telephony. Qualitatively, radio is one of the simplest phenomena in electrical science. Electro-magnetic induction and electro-magnetic radiation have been known for many years. Quantitatively, radio presents one of the most difficult problems with which the engineer is confronted.

Early Problems of Radio Largely Qualitative

During the first quarter century of radio telegraphy and telephony the major portion of attention was given to the sheer working of the system. The problem was to find the instrumentalities which would generate and radiate electro-magnetic waves on the one hand and receive them on the other. The third element in a communication system, namely the connecting circuit, in this case space, had received little practical consideration. From the standpoint of the transmitter there was considerable quantitative information, and power ratings could be assigned to the high voltage transformers and the condensers in the early spark systems; likewise power ratings could be assigned to the Poulsen arc transmitter and to high frequency generators, but from the standpoint of the receiver there were too few data to warrant stating the order of magnitude of the received signal power necessary to actuate it. There was no generally accepted technique and unit for measuring signal strength. Sommerfeld, a theoretical physicist in Germany, and Austin of the United States Bureau of Standards, had developed formulae for attenuation of electro-magnetic waves, but by and large, little was known about the distribution, attenuation and absorption of such waves.

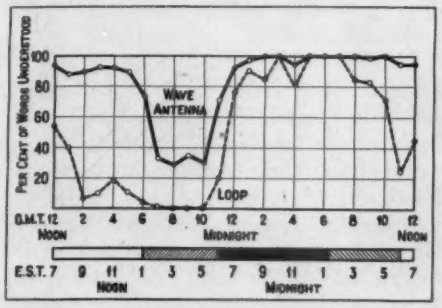
The Vacuum Tube Changes Trend of Radio Developments

In 1912, development was begun of the vacuum tube as an amplifier for long distance telephone lines. Transcontinental telephony was the result, opened to the public in 1915. Coincident with the use of the vacuum tube amplifier in wire lines, it had been realized that this same instrument was the keystone in the future development of radio telephony. Special attention was, therefore, bestowed upon vacuum tubes as a part of the radio transmission system. In 1912, the vacuum tube was a fragile, unstable and weak device. Subsequently, it became a sturdy, reliable and much more powerful piece of apparatus, and by 1915, 25-watt tubes were being used. The mere fact that vacuum tubes were now talked about quantitatively, were rated as other items of electrical apparatus, in terms of power, impedance, current, etc., was a big advance.

Pioneer Tests in Long Distance Radio Telephony

With the heritage of much pioneer work by many workers in the field of radio, the first successful experiments in long distance radio telephony were carried out by Bell System engineers in 1915, resulting in the reception of

intelligible speech in Paris and Honolulu, transmitted from Washington, D. C. The versatile vacuum tube, functioning in both transmitter and receiver on this occasion, played a quadruple role as modulator, oscillator, amplifier or detector.



TRANSATLANTIC
RADIO TELEPHONE MEASUREMENTS
Comparison of reception on wave antenna and loop

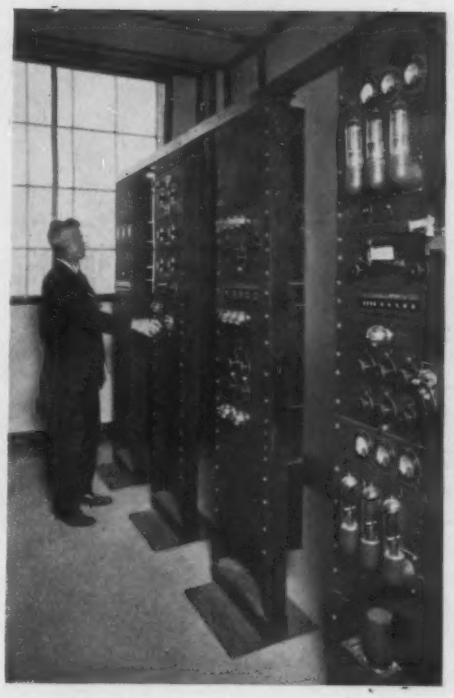
These tests warranted the conviction that sooner or later a serious attempt would be made to bridge the Atlantic Ocean by radio telephone service which could be made available to the public at large.

While the 1915 experiments were successful, they also served to emphasize the tremendous difficulties which had to be overcome. They served to make clear the fact that the transmitter and receiver and the connecting circuit must be studied in the abstract, from a quantitative point of view, before regular and reliable telephone calls could be made from any subscriber in the United States, at any time, at a reasonable cost, to subscribers in certain parts of the Old World.

Single Sideband Suppressed Carrier System

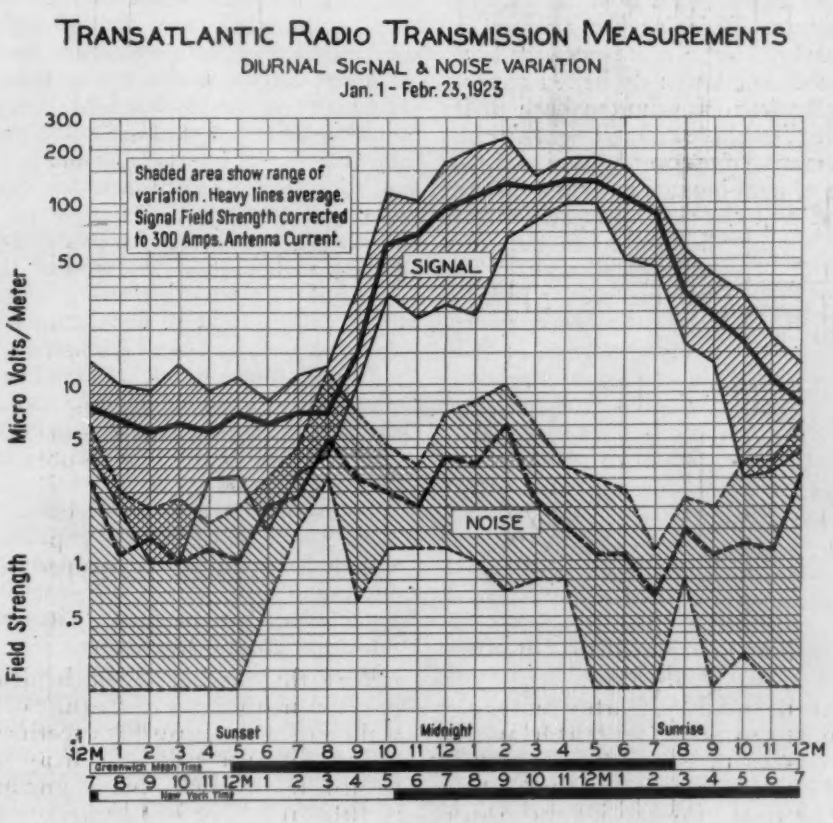
By 1921, when active tests in transatlantic telephony were resumed, subsequent to the war, a much more powerful vacuum tube amplifier became available by the perfection of a water-cooled vacuum tube, having a power rating of 10 kilowatts, about 400 times that of former tubes. At the time of the resumption of tests in transatlantic telephony it was obvious that the first requirement was for a transmitting station that would be sufficiently powerful to deliver satisfactory signals on the other side of the ocean.

Since the amount of power required to do this was unknown, it was decided to construct a transmitter which would be as large as economically reasonable for a commercial undertaking. It appeared that about 20 of the 10-kilowatt water-cooled tubes were as many as could reasonably be expected to work satisfactorily in parallel combination. When a definite power rating and economic limit to the size of the transmitting station had been decided upon, the problem of most effectively using this power was considered. The method used in radio telephone transmitters for broadcasting was studied. It utilizes a carrier wave of radio frequency which is modulated by the speech wave. The resulting radiation from the antenna comprises three components, the original carrier wave together with two wave groups known as sidebands, each of which embodies the frequencies necessary for voice transmission. The carrier wave bears no intelligence, but the complete message is transmitted in duplicate since each of the sidebands contain the entire message. For good transmission in broadcasting by this method, it is necessary that a major portion of the power be assigned to the non-message bearing carrier wave. These principles permitted making the 200-kilowatt station become more effective by eliminating one of the sidebands and the carrier, the entire power capacity of the transmitting system being concentrated on a single sideband. By utilization of this system the 200-kilowatt transmitter became, in actuality, as effective as a 600-kilowatt transmitter of the usual type.



ROCKY POINT TRANSMITTER
Speech input, modulating and single side band suppressed carrier equipment. First amplifier at extreme right

Simultaneously with the development of this transmitting apparatus and the utilization of the single sideband suppressed carrier system, the art of measuring the strength of received signals and the amount of static or radio noise present at a receiving station had been developed.


TRANSATLANTIC RADIO TRANSMISSION MEASUREMENTS
DIURNAL SIGNAL & NOISE VARIATION
Jan. 1 - Febr. 23, 1923
Shaded area show range of variation. Heavy lines average. Signal Field Strength corrected to 300 Amps. Antenna Current.
SIGNAL
NOISE
Micro Volts/Meter
Field Strength
300
200
100
50
10
5
1
.5
.1
Sunset
Midnight
Sunrise
12M 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12M
Greenwich Mean Time
7 8 9 10 11 12M 1 2 3 4 5 6 7 8 9 10 11 12M 1 2 3 4 5 6 7
New York Time

The Problem of Noise or Static

The telephone engineer's fundamental obstacle is not distance alone, as one might think, but the combination of

(*Continued on page 218*)

Industrial Applications of the Electric Furnace

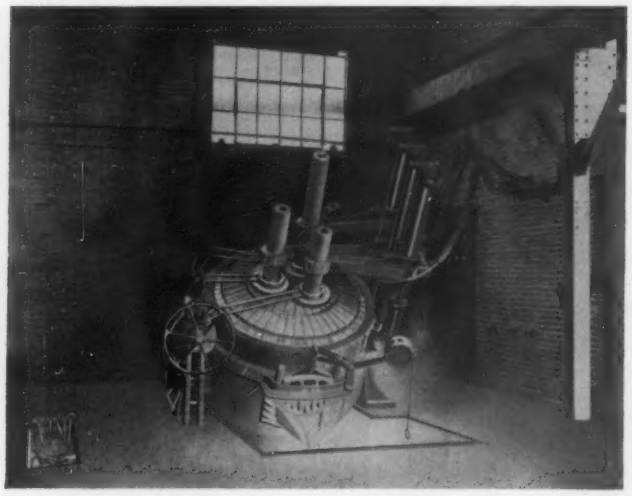
The performance of the electric furnace as compared with other metallurgical processes

By H. H. WATSON
Metallurgist, Pittsburg Electric Furnace Corporation

THE uses of the electric furnace in industrial work have now become so varied and widespread that it would be impossible to attempt to cover the entire field in any one article. Electric furnaces are used for melting irons, steels, non-ferrous metals and alloys, for the production of ferro alloys and carbide, in the heat treatment of iron and steel, in ceramic work, for enameling and many other uses. In general, it may be said that wherever the application of heat is necessary there is some form of the electric furnace. Usually, electric furnaces are made in three types, namely: the arc furnace, the induction furnace, and the resistor furnace. Electric arc furnaces use more power than any other type of electric heating apparatus.

This article discusses only the arc type furnace as applied to the melting of iron and steel, and manufacture of ferro alloys and carbides.

The electric furnace for melting iron and steel, as a practical tool of modern industry, is not a recent invention, as numerous experiments were tried out on various forms, and the great possibilities foreseen many years ago. However, it is only comparatively recently that it has attained great importance in the iron and steel industries. The experimenting dates back as early as 1800 when, shortly after Volta devised the electric battery, Sir Humphrey Davey began experimenting with the electric arc and the electric furnace in a very small way. From then on there continued numerous experiments, a few of which are listed here.



EARLY TYPE 'LECTROMELT FURNACE

In 1839 Robert Hare produced small amounts of calcium carbide and also graphitized some carbon in an electric furnace of the arc type. In these early experiments, current supplied by batteries was used, consequently the cost was very high and the quantity of product small. About 1867 the dynamo was invented and larger quantities and cheaper electric power at once became available.

From 1878 to 1882 William Siemens experimented with an electric furnace of the arc type, consisting of a carbon electrode projecting down into a graphite crucible containing the charge. Direct current was used and was supplied from an individual generator. He made heats of steel as large as one hundred pounds and melted as much as eight pounds of platinum, thus showing the possibilities of the electric arc furnace for high temperature work.

About 1885 the first double electrode electric furnace was built and produced aluminum, copper, steel, and other alloys, from their ores.

In 1886, Hall in America and Heroult in France almost simultaneously developed a furnace for the production of aluminum. This furnace was not of the arc type but of the resistance type, and aluminum was deposited electrolytically from the molten bath of its ores. When a company was formed for the manufacture of aluminum, the price of aluminum was over $5.00 per pound and the day's production was locked up in the office safe each night. The production for 1884 for the entire country was only about 250 pounds. These figures are somewhat amusing when compared with the present price of aluminum which is now approximately twenty cents a pound and the production which now totals over 300,000,000 pounds per year.

In 1888 W. E. Moore first began his electric furnace experiments. He melted steel, copper, and platinum experimentally as well as prepared various ferro-alloys and also did quite a variety of arc welding work.

The year 1892 saw the beginning of several more interesting experiments with the electric furnace. Moissan in Paris made carbides, reduced many metals from their ores, and even made diamonds of miniature size. While no commercial results followed directly, Moissan's experiments received widespread publicity and did much to broaden the interest in the electric furnace. In the same year Thomas Wilson, a Canadian, made a furnace for the smelting of aluminum which, while unsuccessful for that work, nevertheless was successful for making

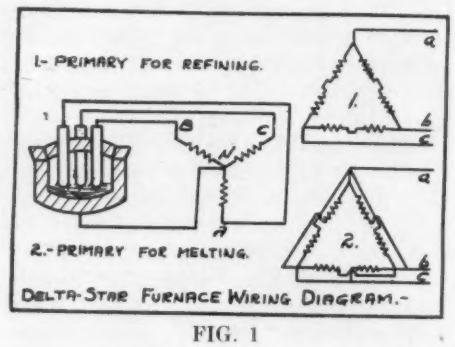


FIG. 1

cuper-alloys, tool steels, and calcium carbide. Wilson's furnace, in a measure, anticipated the Heroult steel-making furnace since he used a system whereby two electrodes were suspended and arced to the molten bath through the slag into the metal and out through the slag to the other electrode.

From 1891 to 1896 Acheson developed and produced a commercial resistance type furnace for graphitizing carbon and in 1898 Stassano of Italy patented and commercially used a three phase radiant arc furnace for smelting iron and steel from the ores.

In 1901 Heroult and Keller in France experimented with their electric furnaces and commercially made tool steel from steel scrap in an arc type furnace.

Following these experiments, the Norwegians built and commercially operated electric furnaces for the production of high-grade pig iron from iron ores. This industry has now attained great importance, for the larger part of the high-grade Swedish pig iron is being made in the electric furnace today. This, in a large measure, is made possible by the use of cheap electric power due to abundant available water power.

In 1909, some of the carbide producers turned their attention to the manufacturing of ferro-alloys. The same general type of furnace was used and ferro-alloys of silicon, manganese, chromium, molybdenum, and tungsten were made. These alloys were of such unusual purity that they rapidly came into extended commercial use throughout the country for use in making crucible and alloy steels. This, the alloy steel manufacturing business, was the beginning of another successful industry which has today reached large proportions.

It was not, however, until 1908 that the electric furnace really began to be a commercial factor in the iron and steel industry and has now become such an important factor in the production of high-quality irons and steels in tonnage lots that it is indispensable.

The three general types of electric furnace in use today are in the order of their importance: (1) direct arc, (2) indirect arc, and (3) induction.

The direct arc type is used almost exclusively in the United States, and in the majority of cases abroad. In this furnace two or more electrodes enter vertically through the roof, and with the customary three-phase furnace each electrode is located in the corner of an approximately equilateral triangle. The arc is struck from the electrode through the molten slag to the bath. In a certain type of furnace, an arc may be struck between any one electrode and the charge, while in other three-phase electric furnaces at least two of the electrodes must contact with the charge before the circuit can be established and the arc formed. Thus, in addition to the heat of the arc, the resistance of the bath and slag generate heat. This type is used largely and is best suited for iron and steel work.

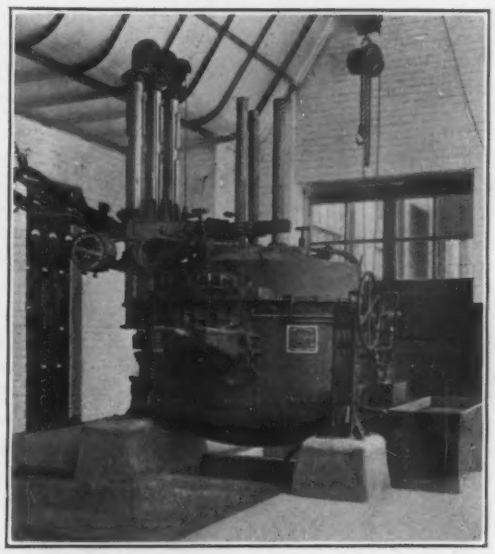
In the indirect arc type, the heat of the arc between two or more electrodes above the charge is radiated to the charge. The great objection to this type is that the heat distribution is uneven and the refractories are subjected to excessive temperatures. This is ameliorated in some makes of this type furnace by rotating or rocking the furnace itself and so agitating the bath that distribution of the heat is promoted.

The induction furnace works on a principle similar to a transformer, with the charge forming the secondary circuit, or induced current loop. This type of furnace has not met with much commercial success in this country, due to various inherent mechanical, electrical and metallurgical difficulties.

In 1909 there were only 13,760 tons of electric steel made or 5/100 of 1 per cent of the total production in this country, while in 1927 the electric furnace steel tonnage reached about 3,000,000 tons or about 3 per cent of the total. Thus, while the total steel production from 1909 to 1927 has quadrupled, the electric steel tonnage increased about 218 times. There is also an increasingly large tonnage of cast iron made in the electric furnace, but this has not as yet reached the tonnage of electric steel.

There are several reasons for the remarkable growth of the electric furnace in the iron and steel industry. The electric furnace has economically met the demand for a more scientific and accurate way of producing uniform and high-grade iron and steel in tonnage lots.

Until 1912 high quality alloy and tool steels were produced in crucibles, or to some extent by the open hearth process. The fact that the acid open hearth does not even partially remove phosphorus and sulphur has greatly restricted its use for quality steels as in most cases these two elements must be kept below a few hundredths of a per cent. This is rather costly in the acid open hearth. The crucible process produces a high-quality steel, but only in small lots of a few hundred pounds and at an extremely high cost.



ONE HALF TON PER HOUR 'LECTROMELT GRAY-IRON FURNACE

When it was discovered that impure raw material could be refined in the electric furnace, and that the steel produced equaled or bettered crucible steel in quality, the electric process received a great impetus and is now established as the leading process for producing high quality alloy and forging steels in tonnage lots.

Many inherent points of superiority account for the growing popularity of the electric process for making irons and steels. One distinct advantage is the fact that the process is extremely flexible, making possible the production of all grades or kinds of iron and steel desired. Perfect control of operation is maintained together with the ability to operate the furnace with the slag and atmosphere reducing, oxidizing, or neutral. Thus, phosphorus may be removed by an oxidizing slag and the sulphur by a deoxidizing or reducing slag. The control of the chemical composition is made easy and accurate, with heretofore unknown close tolerance limits, the alloy loss is minimized, consequently it is easy to meet specifications for chemical and physical requisites. The deoxidizing conditions possible permit the production of a metal very free from dirt, gas inclusions or oxidation defects. The high temperature, due to the source of heat being the electric arc, promotes the rapid completion of the necessary reactions between the metal and the slag.

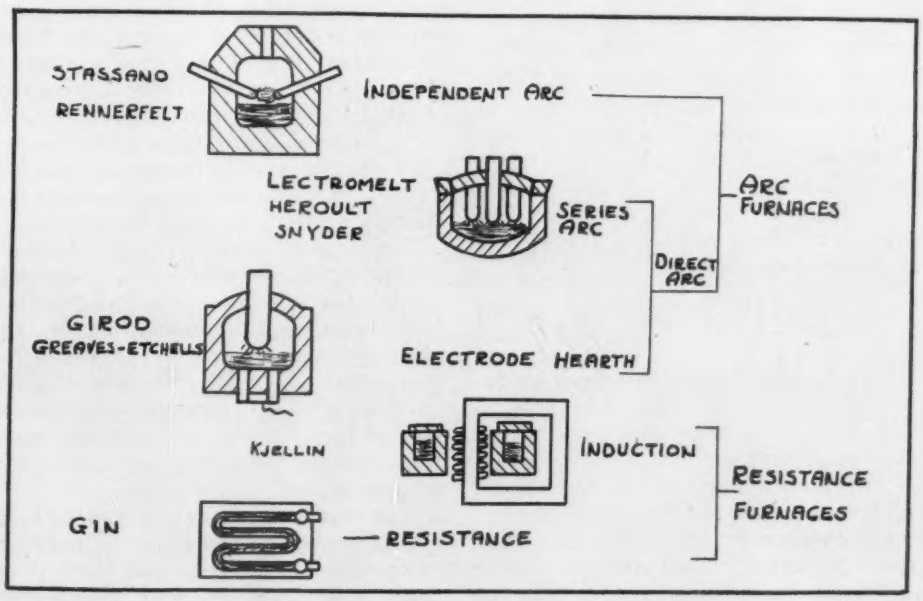


FIG. 2. ELECTRIC FURNACE CLASSIFICATIONS

The iron or steel can be poured in a quiet or "dead" condition, enabling the making of intricately thin sections regularly and with a very low percentage of rejections. As a result, electric iron and steel castings are now used in many fields not open to castings made by other processes.

The electric furnace makes possible the rapid melting and refining of turnings, flashings, chippings, borings, and other grades of scrap costing considerably less than that required for an open hearth or cupola charge, and turns out a product recognized as superior to the highest grade made in the open hearth or cupola.

The loss of metal in melting and refining is also less, the losses in an electric furnace running from 2 to 5 per cent as compared with a loss of 6 to 9 per cent in the open hearth and 16 to 24 per cent in the cupola-side-blow converter process of making steel. There is no sulphur pick-up in the electric furnace.

The following table gives some interesting results of tests made on electric furnace steel and open hearth steel of the same analysis.

	Open Hearth Steel	*Electric Steel*	*Per Cent Increase*
Elastic Limit	41,060 lbs. per sq. in.	64,850 lbs. per sq. in.	58
Tensile Strength	89,100 lbs. per sq. in.	105,140 lbs. per sq. in.	18
Reduction of Area	31.7%	52.3%	65
Elastic Torsion	16,750 lbs. per sq. in.	33,700 lbs. per sq. in.	100

Electric furnaces for iron and steel making are divided into two general classes, *i.e.*, acid lined and basic lined. These, in turn, may be used for one of two methods for producing iron and steel, *i.e.*, by the cold scrap batch method, in which scrap is charged into the furnace, melted and refined, or by the hot metal or duplexing process, in which molten metal from an open hearth or converter is charged into an electric furnace for complete refining or where a cupola charge is placed in an electric furnace for refining.

In basic electric furnace as in basic open hearth practice, the furnaces are lined with burned dolomite and magnesite, making a lining which is resistant to the action of the lime fluxes used. These fluxes are carried as a molten blanket on top of the bath for the purpose of taking up the phosphorus and sulphur. The operation is divided into two periods, namely, the oxidizing period and the deoxidizing period. During the oxidizing period the following reactions take place in which the silicon, manganese, phosphorus, and carbon are oxidized.

(1) $Si+2FeO=SiO_2+2Fe$
(2) $Mn+FeO=MnO+Fe$
(3) $MnO+SiO_2=MnSiO_3$
(4) $FeO+SiO_2=FeSiO_3$

The silicon and manganese are oxidized, as in reactions (1) and (2), and the manganese and iron silicates rise to join the slag, as in reactions (3) and (4). The oxidation of phosphorus takes place as follows:

(5) $2P+5FeO=P_2O_5+5Fe$
(6) $P_2O_5+3FeO=(FeO)\ 3P_2O_5$
(7) $(FeO_3)\ P_2O_5+3CaO=(CaO_3)\ P_2O_5+FeO$

and the carbon is oxidized as follows:

(8) $C+FeO=CO+Fe$

The oxidizing agent commonly used is the rust on the scrap, plus iron ore, or mill scale purposely added when the melting is complete. The lime is not necessarily added with the charge, but can be introduced when the bath is partly melted.

The phosphorus is first oxidized into phosphoric acid which in turn is oxidized to ferrous phosphate. The high calcium slag present under these oxidizing conditions, and at not too high a temperature has a great affinity for the phosphorus and absorbs it to form calcium phosphate so that this undesirable element is thus removed.

Since the oxidation of phosphorus is an exothermic reaction, it takes place before the oxidation of the carbon which is endothermic.

During the "oring down" period the rapid evolution of carbon monoxide causes a stirring action in the bath known as the "boil."

After oxidation is complete the first slag is removed as completely as possible and a new one made up by adding lime, powdered coke, and a little fluorspar for fluidity. At the high temperature of the arc the carbon reacts with the lime to form calcium carbide, a strong reducing agent. This second slag has characteristics common to no other steel-making slag. This carbide slag under high heat has a great affinity for sulphur, and carries it off from the iron or steel to form calcium sulphide which is stable and is dissolved in the slag.

$$2CaO+CaC_2+3\left(\frac{MnS}{FeS}\right)=3CaS+2CO+3\left(\frac{Mn}{Fe}\right)$$

The carbide slag also serves to deoxidize the bath completely and to free it from ferrous oxide and other foreign impurities.

This second slag removes the second undesirable element from the charge, making the electric furnace a positive dephosphorizer and desulphurizer which is an advantage found in no other iron- or steel-making process.

In the acid-lined furnace, the lining is of silicious material and no phosphorus or sulphur is removed, while the silicon and manganese are removed as in the basic process and the carbon is oxidized by the addition of iron ore. The acid process, which differs essentially, as above stated, in detail from the basic process, finds its greatest use in the making of iron and steel for castings and is more rapid and less expensive than the basic method.

Acid slag runs about 55 per cent silica, the remainder being made up principally of ferrous and manganese oxides. The basic slags run about 45 per cent calcium oxide, about 20 per cent silica and the balance ferrous and manganese oxides. The CaO and SiO_2 combine to form $Ca\ (SiO_3)$ but the iron and manganese oxides are, in the main, uncombined. In the case of the acid slag, the iron and manganese oxides combine and tend to form silicates and are thus not active oxidizers.

The electric furnace made its debut in the tool and alloy steel fields and its great success here led to its adoption in the steel-casting industry where still further success was had. Having thus qualified from the standpoints of quality and economy, it was adopted, and is now established, in the gray iron industry.

The increasing interest in better grades of gray iron evident today, is due to the increasing strictness of specifications and to the competition of steel and malleable foundries. The electric furnace first entered the gray iron foundry about the time of the World War and since that time has become firmly established, as a standard means of melting and refining gray iron.

The field of gray and alloy irons is one far larger than any heretofore entered upon by the electric furnace; in fact, the total value of gray iron castings made annually is about four times as large as that of steel castings. Since 1917 there has been a growing interest in electric irons made by both the cold-scrap and duplex processes so that electric iron is becoming as well known in the gray iron foundry as electric steels in the steel foundry.

There are three natural factors which emphasize the advantages of electric furnace gray iron, namely, the limitations of the cupola, increasing strictness of gray iron specifications and economy of production. This combination of causes has been effective in the decision of numerous gray iron foundry men for electric melting equipment.

For many purposes the cupola is a cheap and rapid means of melting irons. It is a widely used furnace in gray iron foundries and melts iron

(*Continued on page 216*)

Editorials

THIRTY FRESHMEN OUT OF NINETY-FOUR

The large increase in the enrollment of freshmen in the course in Aeronautical Engineering may all very well be a healthy sign of the growing interest in one of our newest branches of instruction. But, at the same time, so marked an increase calls for a closer examination of the situation. This fall, ninety-four signified their choice of Course XVI when entering the Institute for their first year, while last September, sixty were registered in the Course.

Such an increase of over fifty per cent in a short twelve months must have certain definite reasons for its existence. Apparently, the phenomenal public interest in aviation which came into being with Lindbergh's sensational flight, has gained, rather than lost its momentum. The daily press, by continually placing emphasis upon aeronautical news, whether or not it may be inaccurately or erroneously reported, has succeeded in creating an air-minded public which today is looking toward the aviation industry as a sort of Aladdin's palace within whose portals miracles and unheard-of riches are to be found.

We wonder how many of our embryo aeronautical engineers are victims of this overnight enthusiasm, their imaginations fired with somewhat indefinite visions of a nevertheless brilliant career and their intentions fixed upon a desire to somehow "get into aviation." Over two-thirds of these men are due for a disappointment next fall, for of ninety-four now registered, only thirty will be admitted to the sophomore year. This limitation is necessary, for the instructing staff and the facilities of the Department of Aeronautical Engineering can only achieve their purpose when the enrollment does not exceed that number for which the course has been planned.

Apparently, few of the freshmen realize that there will be a day of reckoning in the not too far distant future, when they may be told that their record justifies their continuance in the course, or that it warrants their exclusion from further work in this line. Last year found fifty-five freshmen in June eligible to enter Course XVI this fall as sophomores, but twenty-five of these men were dropped in order to keep the registration within the prescribed limits. Next year the casualties will be still higher, and, at this time, the freshman should analyze his motives and desires to determine whether or not he really wants an aeronautical degree for his future work.

For a man who wants to be a pilot or play an active part in flying operations, the course here is hardly suited. It is theoretical in nature, being concerned chiefly with the principles of flight and airplane design rather than with a wealth of practical experience and information. Its graduates have gone into airplane factory engineering, research or technical work in the civil service, or teaching and private research. As a means to get rich quick, it offers no greater opportunity than almost any other line of engineering pursuit, given an equal amount of training and equal ability.

On the whole, we feel that a large number of the freshmen in Aeronautical Engineering fail to realize the true nature of the profession into which they hope to enter or the characteristics and purposes of the course they wish to take here at M. I. T. Now, at the start, is the time to look seriously into the matter, forgetting the glamour in which popular opinion has clothed the subject of aviation, and appreciating the true facts before them. With their minds determined to continue in aeronautics, they have still to face the problem of securing a sufficiently high scholastic grade to insure their position in the upper thirty next June.

A PROFESSIONAL ACTIVITY

Among the numerous problems which confront the freshman on his entrance into the Institute is the choice of an activity. Many have already made up their minds, come out as candidates, and are now working for positions on the staffs of our various student organizations. A large number, however, have not as yet come out for an activity, and to these THE TECH ENGINEERING NEWS offers an unusual opportunity.

No other undergraduate activity offers so well-balanced a combination between school and activity life as the T. E. N. While enjoying all of the benefits which accompany any sort of extra-curricular work, at the same time, the members of the organization are constantly in contact with many phases of the engineering profession. As the scientific journal of the undergraduates, it is their magazine, to improve to the best of their ability. Working along engineering lines, much valuable knowledge and training is secured, so that the T. E. N. may well be called an activity that is also a profession.

The competition for the staff positions in the business and editorial departments is now open. A variety of work is offered along many lines, and a man is certain to find some type of work which appeals to him and which he can do particularly well.

All are welcome to try out for a position on the magazine. The office, in the basement of Walker, is open from 9 a.m. until 6 p.m., and a prospective candidate will be sure to find someone who will be glad to explain the organization to him in detail.

A PLACE IN THE SUN

It is interesting to note, regardless of political affiliations, that the present campaign signalizes the increasing importance of engineering in politics. We see an internationally known engineer running for the highest office in the land, and his engineering training is advanced as an argument that he is especially well-fitted for the position of President. Legal and political training, long held to be the chief requisite for this office, have made room for, or at least admitted the importance of, a technical education. On all sides we hear praises of the engineer, his ability to think logically and clearly, quantitatively, as well as qualitatively, and his skill in "handling men and materials." And after all, what is the President's job but the handling of men and materials?

Of even more significance, in our opinion, is the wide publicity given to engineering questions of public interest and the incorporation of various planks in the platforms of both parties which deal solely with engineering problems. Both parties have announced plans for a nation-wide system of waterways which will aid the farmers, decrease unemployment, and increase the efficiency of our transportation system. This is a splendid example of the far-reaching effect that engineering can exert on our national prosperity. Furthermore, we have the Boulder Dam question which has long been "front page stuff" and we hear constantly of Muscle Shoals, the St. Lawrence waterway project, and Mississippi River flood control.

Engineering and its tremendous effect on national welfare and prosperity was once as little appreciated by the man in the street as the treasurer's annual report. Today, however, it is being made the issue in many local elections and assumes a great national political significance. It seems that engineering is at last assuming its rightful place in the sun.

The Engineering Field

Abstracts from the leading professional and trade journals

The Toltec Dam in the Luni mountains, New Mexico, has drawn a great deal of attention due to the difficulty worked under in placing concrete in the winter time, and at an elevation of 8,000 feet. The dam is of the arch type with a gravity section abutment at one end. It is 78 feet high above the bed of the stream, and 500 feet on the crest. The reservoir formed by this dam will have a capacity of 55,000 acre feet.

In constructing this dam all concrete was placed by chuting. The mixer and other equipment were placed on the bluff about 200 feet above the bed of the stream. Concrete placing was continuous during the winter with the exception of a very short period in late December and early January.

During the cold weather when it was necessary to keep the mixture above freezing the water was first heated to 200° F. by waste steam. An open flame gasoline torch was constructed and set upon the mixer frame, with the flame directed against the rising side of the drum and through the falling concrete.

In starting, the drum of the mixer was filled with hot water and the torch turned on full. When the boiling point was reached the water was poured down the chute and a batch put in the mixer. The time of mixing and heat applied by the torch was adjusted to give a mixture of 85° F. at the point of placing. In no case did the temperature at the mixer exceed 115° F., and as the chutes varied in length from 400 to 600 feet the loss of heat varied, but the drop in temperature was such as was desired at the point of placing.

The forms used were of heavy four-inch plank covered with No. 18 sheet iron. Tarpaulins were spread over the top of the fresh concrete and until the sudden drop of temperature in the middle of the winter this protection was ample.

With the drop in temperature salamanders were placed under the tarpaulins, but did not serve their purpose, as the concrete froze a few inches deep on the top. During this extreme cold work was stopped, and when work was again resumed it was found that thawing and resetting made very little chipping necessary.

Courtesy of *Engineering News Record*

THE TOLTEC DAM IN NEW MEXICO

Stores 55,000 acre feet of Snowwater or Bluewater.—Toltec Irrigation District..

The Cracking of Paint Films can be detected by means of a new apparatus developed at the Bureau of Standards. It determines when a paint, varnish, or bituminous coating on a metal panel has failed by cracking, as such failures cannot ordinarily be seen with the aid of the naked eye. A metal panel is coated on one side with the paint a set of head phones is connected in series with the back of the panel the painted surface is stamped with a number of drops of a conducting solution prepared so as to wet the surface, and voltage from an interrupted source is placed across the head phones and the panel, and the circuit completed by touching the return wire to the drops. When a break occurs in the paint film a loud buzz is heard in the phones.

A Diesel Airplane Engine has recently been built for the first time by the Packard Motor Car Company. It is the product of several years of experimentation and its performance during the initial tests recently conducted was entirely satisfactory.

The engine is a radial air-cooled type developing two hundred horse power.

The application of the Diesel principle to aircraft purposes has long been considered by engineers, but the idea was usually rejected because of the great weight believed necessary for successful operation. This made the engine impracticable for airplane use. The Packard engineers have succeeded, however, in reducing the weight from one hundred pounds to three pounds per horse power, where it can be satisfactorily utilized. At the present time no details can be obtained concerning the construction of the engine or its operation. Further and more exhaustive tests are to be conducted before it will be introduced on the market.

The new power plant embraces many advantages over the present type of internal combustion motor. Probably the most important of these is the elimination of the fire hazard, for the type of fuel it uses is not combustible in its ordinary state. Having no electrical ignition, the radio interference now experienced during the inter-plane communication will be eliminated. The engine is said to have fewer parts than the simplest gasoline engine. The fact that it will carry an airplane twenty-five per cent farther per pound of fuel is also to be considered from the viewpoint of economy of operation and increased radius of flight.

Paper and the Farmer are two subjects which, in the past, were never linked together. That is to say, the former was of not much significance to the latter's field of work. However, according to the results of experiments by the Department of Agriculture, paper will be a great help to the farmer in the future.

The use of paper in farming was first introduced on a large scale by the Hawaiian pineapple growers, and at the present time, 30 per cent of the pineapple crop in Hawaii is raised in ground literally blanketed with paper.

The paper used is of a tough nature and is impregnated with asphalt. The paper is unrolled on the ground, and a small amount of earth is turned up over the edges to act as ballast so that it will not be disturbed by the wind. The usual system then followed is to puncture the paper and place the pineapple slip into the ground right through the hole in the paper. However, the

slips are sometimes planted in the open slat between the strips of paper. The growers have found that this system gives them a 30 per cent higher yield, and one needs no further evidence to its practicability when informed that close to $500,000 has been spent for paper in Hawaii alone for this purpose.

The use of paper mulching, as it is called, is not limited to the growth of pineapples alone, however, for the experiments at the government farms have shown that it may be applied to a large number of crops.

Among the many reasons the paper mulching is so successful is that it does not allow weeds to grow; that it tends to drain the moisture to the planted area; that it tends to help hold the moisture; and that it helps to heat, and to hold the heat in the ground. This last factor is of great importance as the activity of the nitrating bacteria, so important to plant life, is increased at the highest temperatures, within certain limits.

Aside from the added yield stimulated, this mulching preserves the original nature of the ground. That is, it is not necessary to turn the earth as often as when the surface is exposed to the elements. It has also been observed that crops mature earlier with this system, thus making it possible to have a second planting.

A Wind-Power Generator of novel design has recently been erected in experimental form in the Coachella Valley of California. Tests conducted during the last few months indicate that it can be as successfully used to utilize the power of the wind as the present day turbines utilize water-power. The present model develops from 150 to 175 h.p.

The device is in the form of a tunnel one hundred feet long. It is fifteen feet in diameter at the larger end. It is mounted on a circular double track on which it pivots to catch the full force of the wind. A slight breeze is developed into a ten to twenty mile current of air in passing through the tunnel and on the way drives an air turbine. This in turn drives an electric generator.

In the region where the tests were conducted weather reports show an operating wind ninety per cent of the time. It is proposed to build machines four times as large as the experimental model. These will be situated in mountain gaps and points wherever wind is prevalent. They will be hooked together on one circuit furnishing continuous power.

The Curtis Chieftain is a new radial aircraft engine representing a radical departure in the design of this type of motor. It is a twelve cylinder hexagonal engine with the cylinders arranged in rows of two.

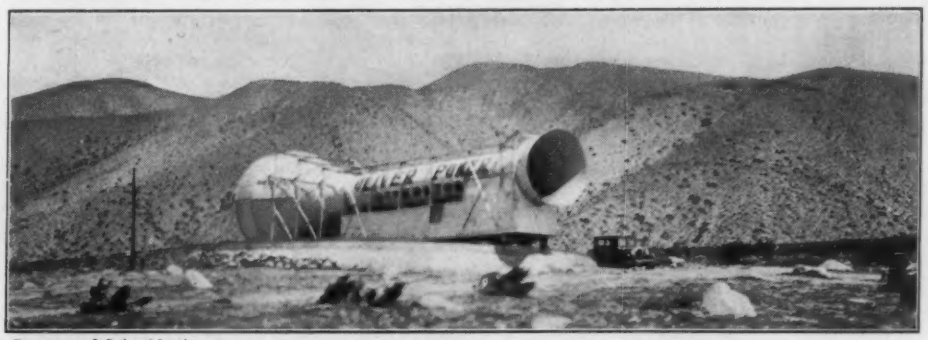
The engine develops six hundred horse power and is the largest air-cooled motor in the country. The most remarkable feature of its performance is that it attains the same speed as could be attained from a water-cooled motor of the same power in the same plane. The frontal area per horse power is about one-half that of the conventional nine cylinder air-cooled V engine.

The motor weighs nine hundred pounds, or only one and one-half pounds per horse power.

A New Shape Cutter employing the oxy-acetylene flame as the cutting tool is being introduced by a New York air products company. It will cut plate, forgings, and ingots up to one foot in thickness. Action is automatic and the cuts produced are accurate and smooth with square edges and smooth faces.

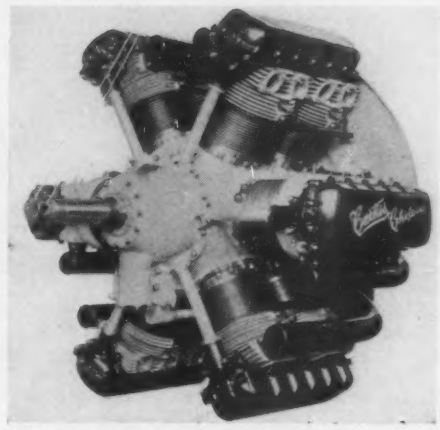
In operation, the cutting blowpipe moves on a carriage which can be driven in any direction by an electric motor. For routine work a template guides the cutter. When only a few pieces of a given design are to be made, the machine can be operated manually from a blue print.

The rate at which the cutting can be done is unusually high, being from three to twenty inches per minute, depending upon the thickness of the material. Production costs with the machine are low, due to the savings effected in time and material as well as in labor. Only one operator is required to attend the machine.



Courtesy of *Scientific American*

THE NEW WIND-POWER GENERATOR



Courtesy of *Scientific American*

THE CURTIS CHIEFTAIN

Neddle-Beam Tunneling has been put in the same category of security as the shield, for quicksand tunnels of moderate diameter. Refinements in the use of needle-beam bracing has made it possible to hold soft ground, virtually a quicksand, in place with radial bracing from a needle-beam to liner plates. The needle-beam offers the most simple and direct system of bracing possible for circular tunnels, and with the use of liner plates of steel or timber the closing of the walls can be made substantially as tight as with a shield. The mechanism and power service required are vastly less complex than those required for shield operation. Where skill and care are exercised, the security of the operation has not proved greatly less, and the speed of construction has been as great, as in shield tunneling.

A Motor Overload Relay, which is actuated thermally, is a new device which has lately made its appearance in the electrical field. It is designed to protect electric motors from burning out when excessive overloads are applied. At the same time, it automatically permits the utilization of the safe overload capacity of the motor.

The device is to take the place of the magnetic over-current relay which has been used for this purpose. This latter type of unit has many disadvantages due to the fact that its operation is dependent only upon the amount of current applied with no account taken of its duration. This means that if the current exceeds normal even for such a short time as to be harmless it will shut down the motor. Starting in all cases can only be accomplished by shunting the relay until the motor speed has been attained.

Since the thermal relay follows the heating curve of the motor in its actions and only acts when a dangerous temperature is attained, all the disadvantages of the magnetic type control are eliminated. In addition, the former is simpler in construction and less easily thrown out of adjustment.

Recent Books

This department conducted in co-operation with the faculty

MATTER, ELECTRICITY, ENERGY. The Principles of Modern Atomistics and Experimental Results of Atomic Investigations. *By* WALTER GERLACH, *o. ö. Professor, University of Tubingen. Translated from the second German Edition by* FRANCIS J. FUCHS, PH.D., *St. Johns College, Brooklyn, N. Y. D. Van Nostrand Co. Inc., New York, 1928. 427 pages, 15 x 23 cm. Price $6.00.*

This is one more book added to the already large number treating in a semi-popular manner of the modern ideas of the structure of matter, or rather, according to the title, it deals with matter, electricity and energy, for all three are today regarded as manifestations of the same thing. The book covers an interesting field of topics. It appears as a series of more or less independent lectures, thirty in all, and consequently there is a good deal of overlapping, which, however, is not at all objectionable. One is glad to find a few topics such as Atomic Rays, Magnetic Properties of Atoms, Superconductivity (that is, the enormous conductivity exhibited by metals at temperatures near the absolute zero) that usually escape treatment in books of this scope.

The book aims at the most profound developments of physics and yet at an elementary and mainly non-mathematical treatment. The achievement of both aims at the same time is naturally impossible. It falls rather further than necessary short of accomplishment because of the assumption of a more complete comprehension of many physical terms and conceptions than would be possessed by the student to whom the book is obviously directed. A good many statements lack clearness, the fault being probably shared between the original and the translation. The greatest usefulness of the book would appear to be as a text for seminar work under a competent leader who would see that all necessary steps in the development were supplied. For such a use the book would supply a great deal of inspiration. It would furnish the essential topics, with an outline of some of the greatest lines of research and the individual achievements of the greatest pioneers and developers in the lines of thought discussed.

ARTHUR A. BLANCHARD.

ELECTRIC CONTROL GEAR AND INDUSTRIAL ELECTRIFICATION. *By* WILLIAM WILSON, M.Sc., B.E., M.I.E.E., A.A.I.E.E. *Author of* "Small Electric Generating Sets Employing Internal Combustion Engines." *Oxford University Press, American Branch, New York.*

This book is a very complete treatise on electric control and industrial electrification as applied to factory operation. It contains a great deal of information beneficial to any electrical engineer, as well as data necessary to the actual designing and setting up of factory electrification apparatus. In this respect it serves as both an engineering textbook and handbook combined. One of its chief assets is that the design data is separated from the text in such a manner that the reader may skip it or easily find the information, as he pleases. The principles of the operation of direct-current and alternating-current machinery are touched upon in order that the reader may be able to read along without referring to another book, but it is assumed that the reader has already studied the subject at some previous time.

First, the author points out the history, advantages, and development of the electric drive, emphasizing its increasing importance in industry. This is followed by two chapters outlining the theory and operating characteristics of direct-current and alternating-current motors respectively.

The author then describes the apparatus for automatically and manually controlling motors used for different purposes. Starters for both direct and alternating current motors are described and explained. The system of series parallel control of series direct-current motors is also carefully treated and explained. The remainder of the first part of the book is then devoted to the discussion of the various fundamental parts of these starting and control systems. The advantages of different metals used in the parts, the design formula for the various parts, and their curves of performance are given and discussed in a clear and concise manner.

The rest of the book is devoted to the design and operation of control systems. Motor-generator control systems are first treated. The Ward-Leonard and Ilgner systems are described and the use of flywheels and slip regulators is explained. Under factory operation we are given the comparative costs of electric and steam drive, along with discussions of motors and control gear for line shafting, group drive, and use in textile factories.

With equal thoroughness the author discusses in turn electric lifts, electric operation of steel works, control of furnace and mine hoists, underground control gear, electric cranes and gantries, machine tool control, control of calendar and printing presses, and such miscellaneous control gear as is used for operating large steam and water valves, electric pumps and compressors, swing and lift bridges, and electric organ blowing.

The book is remarkably complete. Every subject and its parts is treated thoroughly — all the way from the main apparatus down through its protective devices to its push-button controls. The problems of design are dealt with clearly and carefully. And the whole book is so admirably arranged that the discussion and data concerning anything in it can easily be found.

GEORGE J. MEYERS, '29

GEOLOGY OF PETROLEUM AND NATURAL GAS. *By* E. R. LILLEY. *D. Van Nostrand Co. Inc., x+524 pages, 1928.*

Dr. Lilley is an associate professor at New York University, and is a lecturer and writer on the geology of petroleum. His latest book is an advanced text on the character of the occurrence of petroleum. It will be a valuable addition to one's library, but will have to be supplemented by books on the geographical occurrence of petroleum; on geophysical prospecting and other methods of field geology; on petroleum engineering, refining, marketing and economics; as these problems are not treated at all or very briefly.

After an interesting introduction in which there is an important paragraph on definitions of terms, a chapter is devoted to the properties of petroleum in which color, density, viscosity, volatility and chemical composition are discussed. There follows a chapter on bitumens, and then a chapter of 35 pages on the origin of petroleum, and another of 25 pages on the conditions limiting its occurrence.

The author concludes that vegetable matter is the major source of the world's petroleum, but he does not believe that it can be considered to be the exclusive source. Great importance is attached to the action of bacteria between the time of deposition of the material and its burial. The intermediate substance, kerogen, is converted into oil by the action of water, pressure and heat in the rocks in which it is trapped.

Chapter VI outlines geological history and discusses the conditions at the time of deposition of the important oil reservoir rocks. The kinds of rocks favorable and unfavorable as reservoirs are described in Chapter VII.

After oil has been formed it has to be concentrated into these reservoir rocks before sufficient quantities can be found at one place to be of commercial importance. This process of concentration is treated in 26 pages. Lilley concludes that the gravitational theory must remain the basis of all theories of the accumulation of oil into reservoirs of commercial value.

Since oil pools occur in relation to definite rock structures, such as anticlines, domes, synclines and pockets caused by faulting, the subject of such structures is treated with care. Their methods of study are described and many examples are given in the course of 130 pages. Porosity, which is necessary to any accumulation, and which determines the amount of such accumulation, is discussed in Chapter XIV so far as it occurs in sedimentary rocks. Porosity between grains, as in sands, is the most important, but other openings in rocks such as the weathered surfaces under unconformable contacts, such as channels formed by different conditions of deposition, and such as joints and fractures are important in some districts. Jointed and fractured igneous rocks that are known to contain oil are described in Chapter XV.

Salt dome structures have become very important oil producers along the Gulf Coast of the United States and Mexico and in Rumania, and the 31 pages of Chapter XVI cover this phase of the subject. In Chapter XVII 70 pages are devoted to the accumulation of petroleum in complex structures. A concluding chapter describes exploration in new areas, and includes a brief treatment of five pages on the subject of geophysical prospecting.

The book is well written, well printed and illustrated. A moderate number of bibliographical references is given, and the index is complete though not elaborate.

J. L. GILLSON.

THE HUMAN HABITAT. *By* ELLSWORTH HUNTINGTON. *293 pages, illustrated. D. Van Nostrand, Co. Inc. Price $3.00.*

The science of geography, as expressed by the modern American school of thought, is the subject of this most interesting book. It is the author's belief that nature is the determining factor in adjusting man to his environment. While the physical surroundings do not compel man to pursue a certain course in life, nevertheless, nature will exterminate slowly but surely those races or people who fail to conform to the way of living best suited to the geographical conditions of their habitat.

By surveying the various factors of land and sea, climate, temperature, humidity, and prevailing winds, the various conditions at different portions of the earth are developed from the standpoint of cause and effect. The author then discusses the many types of people which inhabit the world. An endless variety of races, nationalities, and tribes are described, from the Eskimaux to the Hottentots, and the Bushmen to the Siberians. Each man is shown against his own background, and the reasons for his survival or his failure to conform to his environment are made clear. The pages of the book are full of intimate accounts of the lives of almost incredibly strange people — small, unheard-of tribes living in some out of the way corner of the earth — so that as a travelogue, it proves to be decidedly interesting reading.

The importance of changing seasons is clearly developed, and the author emphasizes the progress of civilization in the temperate zones. The harmful effects of unchanging climate, either in the Arctic or the Tropics, is discussed.

Concerning it, Edwin E. Slosson says: "There is no other book in English which covers this field although it is one of the most important subjects from an educational, industrial, or political standpoint."

. . . with their feet on the ground

MEN of vision, yes. But don't overlook the fact that those old Roman road builders and empire builders kept their feet firmly fixed on the ground. They faced the facts squarely. They were demons for detail. They were the world's first great organizers.

Pioneering in the telephone industry is like that. It is a work of vision and of leadership into new fields. But back of it all must be the ability to organize men, money, material and machines.

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Capacity to Apply

(*Continued from page 199*)

councils and on boards. Those possessed of suitable capacities should fit for the engineer's part in the guidance of affairs.

To aid engineers in doing their share toward solving human problems raised by science and its applications, some of the coöperative research energies of the profession should be directed to studies of the inter-relationship of engineering, sales effort, personnel, credit and other factors of modern industry and merchandizing. In these theatres for investigation there are inversions and obscurations of conception and statement which are hindering progress. To analyze situations and then state problems clearly is a customary task for engineers.

Engineers know more about the mechanisms, processes, and organizations which they have brought into being than do others; but even they need to study with broader outlook and deeper insight the "human problems" that have arisen. How can the multiplying means for lightening burdens, for reducing waste, for increasing wealth, for making life freer and happier, be utilized without imposing hardships upon large groups during periods of inept adjustment? Why are there complaints of over-production, with its waste, side by side with scarcity? Why wailing of unemployment when every mother's son longs for escape from drudgery? How are blessings created by science and engineering turned to banes?

Minds and hands that essay to direct the Sun's chariot should be so well trained that some of the Creator's children will not be scorched while others are benefited. In study of these problems engineers and men from other fields of learning and experience should collaborate.

Engineering Foundation, having given consideration to "human elements" in engineering and industry, may well be the instrumentality of the profession for larger-scale, better defined, more scientific study of these "human problems." Massachusetts Institute of Technology has established a chair of humanics and has chosen an engineer to occupy it. A plan for effective action is suggested. Let Tech equip its department of humanics for worthwhile research. Then let this leading engineering college and the joint research organization of the profession unite in supporting and directing continuous investigations in this field of learning which so much needs the engineer's contribution. Foundation and Tech together, upon giving proof of serious interest, could enlist coöperation of engineering, scientific, industrial, economic, personnel, management, financial and educational organizations.

William E. Wickenden, director of the current coöperative study of engineering education, reports that in at least one European country the engineering schools have accepted the duty of investigation of human factors in production; but such investigation does not go far enough. American conditions, furthermore, differ from those in Europe. Our problems must be solved amid American environments. New bodies of knowledge are needed, which only research can supply, in order that there may be an adequate basis for teaching. Our capacities to observe, generalize and apply must be concentrated also upon these human elements of civilization.*

The capacities to discover, to generalize, to apply, to accumulate, benefit mankind. Each feeds into the others through the medium of coöperation. Engineering Foundation was designed to effect coöperation of men and organizations having these great capacities. We have outlined some of its endeavors to fill its place in the world. Persons of discernment in this country and abroad have perceived its great prospects and have expressed appreciation for what it has done. Its usefulness will be greatly enlarged — how rapidly depends upon the comprehension of its potential benefits, by engineers and those who profit from engineering. Willingness to provide will follow comprehension and will build up this community trust for energizing the contributions of personal effort and professional talent, which so many engineers are willing to make. Through coöperation with many bodies in a broad variety of investigations of human and physical problems, the Foundation aims to help engineers to realize their position in the social order and to meet their obligations towards their locality, their country and the commonwealth of the nations.

The ideal for Engineering Foundation conceived by its Founder is a community trust of great resources, accumulated from many donations, administered by the best wisdom of the profession expressed through two boards carefully selected by the societies, one to conserve the capital funds, the other to be the agency of the societies for combining in the service of mankind, amid the ever-changing conditions of an advancing world, necessary resources and the "capacity to apply."

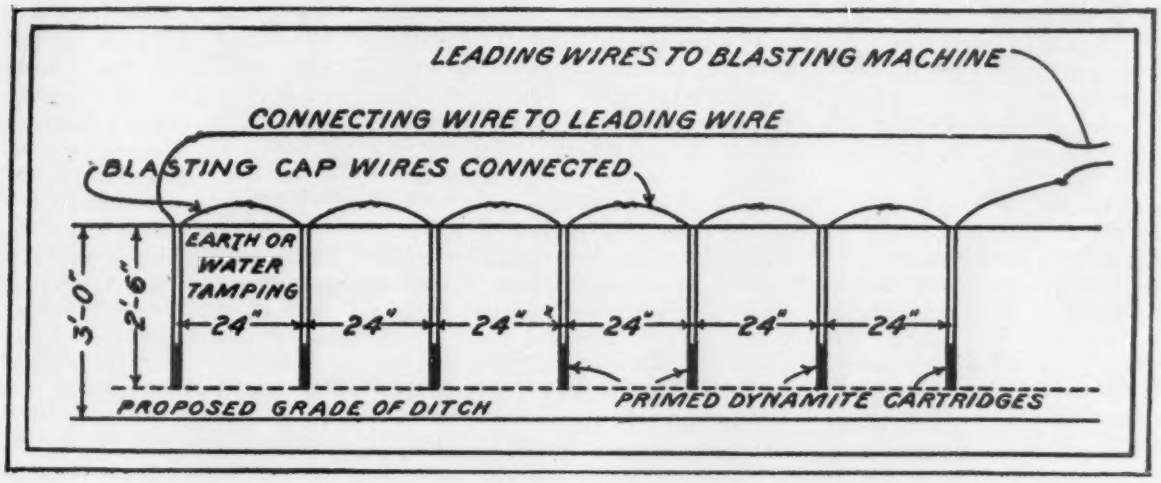
A catalogue of activities of Engineering Foundation and a directory of the personnel of its board and committees would be interesting to some persons. We have preferred, however, to present the Foundation differently to the readers of THE TECH ENGINEERING NEWS. Nevertheless, as institutions are molded by the men who lead them, the names of the chairmen and vice-chairmen will be informative. Lewis B. Stillwell, consulting engineer, Past-President American Institute of Electrical Engineers, member of the Civil Engineers, a trustee of Princeton University, is Chairman. George A. Orrok, '89, consulting engineer in power and power development, member of the Civil, the Mining and Metallurgical, and the Mechanical Engineers, and Arthur D. Little, '85, President of Arthur D. Little, Inc., Past-President American Chemical Society and American Institute of Chemical Engineers, member of the Mining and Metallurgical and the Mechanical Engineers, trustee of Massachusetts Institute of Technology, are Vice-Chairmen.

Past-Chairmen are Gano Dunn, President J. G. White Engineering Corporation, Past-Chairman National Research Council, Past-President American Institute of Electrical Engineers; Michael I. Pupin, Professor of Electro-Mechanics at Columbia University, Past-President American Institute of Electrical Engineers; W. F. M. Goss, '79, Past-President American Society Mechanical Engineers (deceased), and Charles F. Rand, Past-President American Institute of Mining and Metallurgical Engineers (deceased).

Past-Vice-Chairmen are Edward Dean Adams, '69, Honorary Member, engineer-financier, John Fritz Medalist, fellow of the Civil Engineers and associate member of the Electrical Engineers; Professor Pupin; J. Waldo Smith, Consulting Engineer to the Board of Water Supply of the City of New York, John Fritz Medalist, member of the Civil and the Mechanical Engineers; Dr. Goss, '79; D. S. Jacobus, Advisory Engineer, Babcock & Wilcox Company, Past-President American Society of Mechanical Engineers; Frank B. Jewett, '03, President Bell Telephone Laboratories, Vice-President American Telephone and Telegraph Company, Past-President American Institute of Electrical Engineers; Elmer A. Sperry, Chairman Sperry Gyroscope Company, John Fritz Medalist, member of the Mechanical and the Electrical Engineers.

*In connection with this paragraph and those immediately preceding it, reference is made to Dr. Wickenden's "Preliminary Report to the Board of Investigation and Coördination" of the Society for Promotion of Engineering Education, 1926, particularly at page 2, and also to a forthcoming bulletin which will deal with comparisons of European and American schools and methods for engineering education.

Ditching and Drainage



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Industrial Applications of Electric Furnace

(*Continued from page 208*)

quite cheaply, but its greatest disadvantages are its well-known metallurgical limitations. It does not bring down uniformly any desired analysis of iron, affords but small opportunity for refining, and fails to bring the iron to a proper superheat for many classes of work. In these important respects the electric process excels the cupola by reason of the inherent differences of heat input and design.

Proper correlation of the various items in the electric furnace and cupola processes shows that the lower charge and labor costs of the electric furnace so balances the lower melting cost of the cupola, that in many localities electric furnace iron is actually cheaper as well as far better than cupola iron.

The superior fluidity of electric furnace iron in addition to assuring strong, sound castings, brings forward another important consideration, namely, that superheated metal so increases feeder effectiveness of risers as to check internal shrinkage and cold shorts. This accounts, to a considerable extent, for the higher yields of good castings had per ton of molten metal in the ladle with electric furnace gray iron castings, as contrasted with cupola irons.

With the electric furnace, all the melting or refining processes possible in an open hearth, Bessemer, cupola, air furnace or crucible can be duplicated under better control and more quickly and accurately. This flexibility is but one of the advantages of the electric furnace which can be operated suitably on either cold scrap or hot metal charges and is for the production of all grades of acid or basic irons and steels. Acid-lined electric furnaces are suitable for economically turning out quality acid steels as well as gray or white irons; in fact, quite a number of users are making these products in alternate heats. Many of the electric furnaces in this country are using the acid process, due to the availability of suitable grades of low-cost scrap melting to the required phosphorus and sulphur limits. Numerous electric furnace installations, basic lined, are making plain carbon and special manganese steel wearing parts for crushers, steam shovels, rolls, and similar heavy service members, steels for corrosion resistance, carbon tool steels, and like basic products.

Electric furnace steel is now regularly being specified in line with rigid safety factors required in the automotive, tractor, airplane, mill and shipping industries, and denotes its established superior tensile and dynamic properties. Electric steel is known by the metallurgist to be denser, more solid and shock-resisting than open-hearth or Bessemer steel; it is freer from blow-holes, slag inclusions, occluded gases, responds more satisfactorily to heat treatment, is freer from segregation, pipes, shrinkage cracks, cold shorts, and decidedly more homogeneous. The torsion and shearing strengths of electric steel are generally greater than open-hearth or converter steels of similar analysis.

Although production costs were at first considered to run higher in the electric furnace, two factors combine to give production costs favorably comparable with cupola, converter and open-hearth processes. The first factor is thermal efficiency. While the cost per B. T. U. developed is sometimes higher in the electric than in the fuel-fired processes, it should be borne in mind that this item is important only as considered on the basis of the 16 per cent open hearth, 35 per cent cupola, and 75 per cent electric-furnace thermal efficiencies. Secondly, the charge in the electric furnace may be proportioned to include percentages of the cheaper grades of charge, such as turnings, borings, flashings, chippings, punchings, foundry returns, light scrap and similar materials, as oxidation is had only by scale, ore and similar additions. These two factors, coupled with using high-tension power at the lower rates for this service, and the reduced alloy additions required, usually result in a cost per ton of metal in the ladle favoring the electric process.

It is generally agreed that the electric furnace has no equal in producing high-grade steels, such as special alloy and tool steels, and the increasing number of electric furnaces installed in steel foundries would indicate that the electric furnace can successfully compete with the open-hearth and converter in producing the commoner grades of steel for foundry work.

The better quality of electric furnace steel is largely due to the control of the reducing, or non-oxidizing, atmosphere and slags within the furnace, resulting in a cleaner and thoroughly degasified steel.

The foregoing discussion has to do particularly with the production of gray and white iron castings and steels, ordinarily produced by cupola, converter, and open-hearth methods. It is in the production of iron for malleable castings that the electric furnace offers even more marked opportunities for quality and economy. The method of melting employed in the production of malleable castings is usually the air furnace, which type of melting unit obviates some of the difficulties experienced with cupola melting, but is naturally more costly. The electric furnace offers all the advantages of the air furnace, and, furthermore, overcomes a number of its limitations.

Ferro-alloy has aptly been defined by Howe as "iron so rich in some element, other than carbon, that it is used as a vehicle for introducing that element, in the manufacture of iron and steel." Ferro-alloys are now largely made in the electric furnace, practically their entire production being used in the iron and steel industry.

Ferro-manganese ranks first in importance among the various alloys used in the iron and steel industry. It is a strong deoxidizer and is invaluable in the production of sound homogeneous steel. Its use dates back to 1839, when it was first used by Heath to improve malleable iron and cast steel made from low grade ores. The first came into real industrial importance about 1856, when the Bessemer process was introduced.

Second in importance among the ferro-alloys is ferro-silicon, which is used as a deoxidizer and degasifier. The pure metals of manganese and silicon are hard to produce and are expensive, while in comparison, the ferro-alloys of these elements are cheaply produced. Another, but more expensive degasifier, is ferro-titanium, which is used for the removal of oxygen and nitrogen.

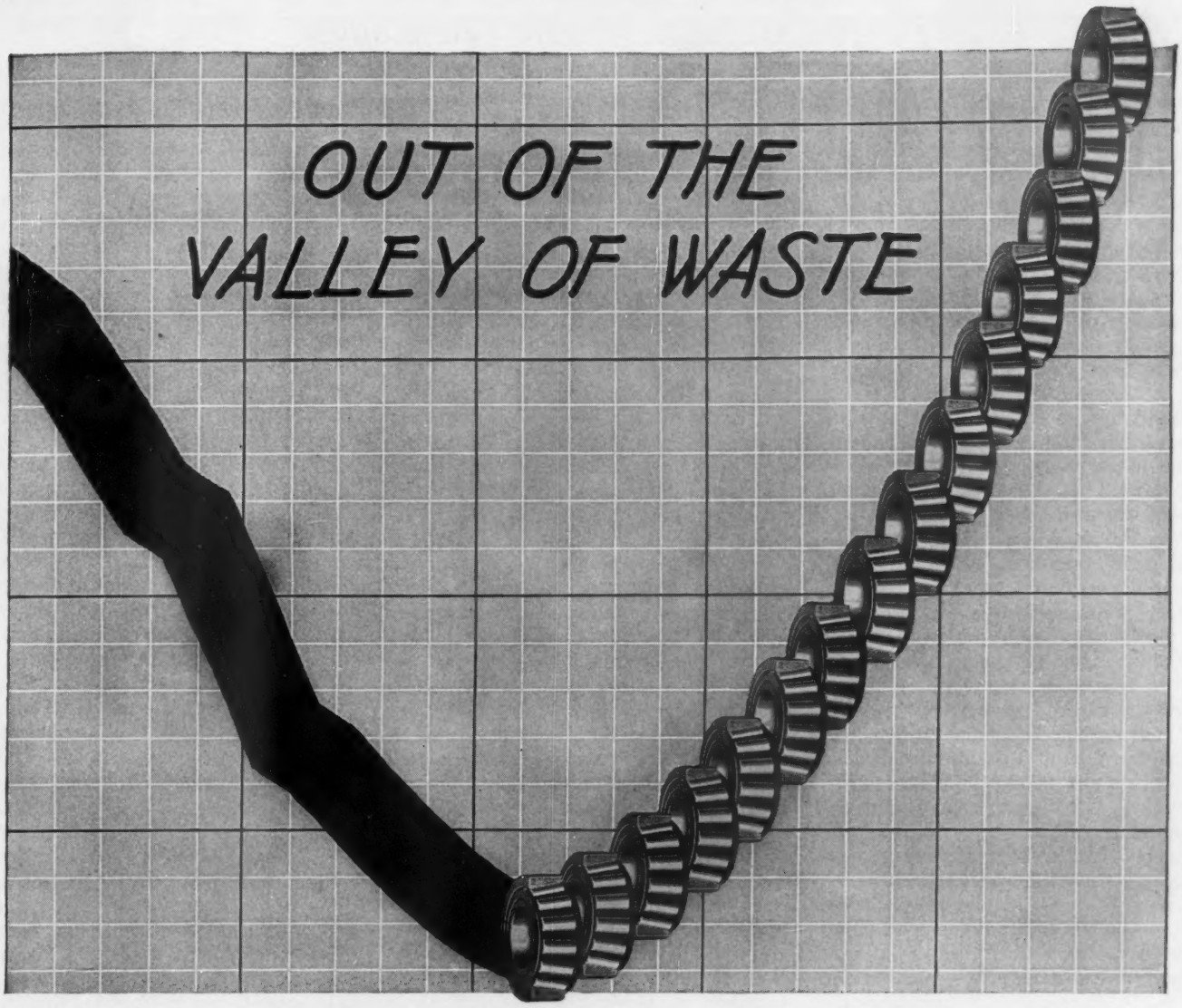
Some of the more common ferro-alloys used, especially in alloy steel production, are the ferro-alloys of chromium, tungsten, molybdenum and vanadium.

Previous to the introduction of the electric furnace, many ferro-alloys were made in crucibles by heating the oxides with reducing carbon.

In general ferro-alloys are now produced by smelting an ore, usually the oxide, of the desired alloying element with scrap iron or iron ore. The iron collects the alloying element and makes it easier to reduce. The ferro-alloy furnaces are usually built with an open top, surrounded by a platform from which the charge is shoveled into the furnace. The furnaces are built either circular with the electrodes arranged at the corners of an equilateral triangle, or rectangular with the electrodes arranged in a straight line. A tap hole is provided at a suitable place with a special electrode gear for melting out the solidified charge at the tap hole, when necessary. Furnaces are lined acid or basic, depending on the product to be made, *e.g.*, for ferro-manganese, ferro-chrome and such it is basic lined, and for ferro-silicon it is acid lined.

Another very important product of

(*Continued on page 224*)



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Transatlantic Radio Telephony

(*Continued from page 205*)

distance with an entirely different kind of thing, namely, noise. If one strings a pair of telephone wires between any two points, these wires will be subject to certain extraneous electrical disturbances, manifesting themselves at the receiver at each end as noise. These electrical disturbances have many origins, natural and artificial. Since noise exists on every telephone line, it is therefore obvious that the telephone engineer must make such arrangements that the telephone message can always be distinguished above the noise of the circuit. The farther along a wire a telephone message travels the fainter it becomes. This attenuation of signal current must be taken account of even if there is no line noise. The transmission of telephone messages over long distances by wire or through space therefore requires that the general power level of the signal will be well above that of the general power level of the noise.

For the radio engineer this relation of signal and noise was a particularly difficult problem. In wire systems the connecting circuit can be subjected to analytical treatment, design and experimental control on the part of the engineer. In the laboratory and field he can create artificial situations which can be repeated and which are favorable to his immediate objectives, as set up by his analysis. In radio telephone systems the situation is somewhat different. The connecting circuit is beyond his province. It is veritably in the lap of the gods. Today, the chief obstacle to radio telephone service between the Old and New World is the lack of a reliable and stable connecting circuit. The atmosphere is the seat of continual and fairly violent electrical disturbances. Currents of electricity pass back and forth between it and the earth. A sensitive radio receiver brings in an astonishing succession of clicks, hisses and crashes. On this side of the Atlantic they are called "static." The Englishman calls them "atmospherics."

The engineer of transatlantic radio telephony is unable to create artificial situations for the study and control of the connecting circuit. There is little he can do with the weather, the seasons, the sun, the earth's magnetic field and lightning discharges. No doubt he would like to enclose the terrestrial globe in a metal shell to exclude cosmic radiation and electrical disturbances, to find out what would happen to radio waves. He might like to have total eclipses of the sun occur fortnightly and decrease the speed of rotation of the earth so that night and day would be five times as long. As he would find it difficult to discover anyone willing to finance such projects, the only alternative is to become a behaviorist, objectively take observation after observation, compile data, plot curves, continue to test month after month and year after year, with the expectation that an analysis of the controlling factors will reveal information whereby long distance radio telephony can be engineered.

In attacking this problem, one of the criteria of signal strength, electric field intensity, was chosen, to be measured in microvolts per meter. This quantity gave information as to the space variation of the voltage embodied in the electro-magnetic waves. The technique and instruments for making field intensity and static measurements made rapid advances. Subsequent experimental work showed that for good reception the strength of the signal should be 100 times as great as that signal which can be just heard through the noise.

The signal strength was found to vary from low values of 1-30 microvolts per meter in the day time up to 10-100 microvolts per meter during the night. What value of signal strength is satisfactory depends, of course, on the amount of noise.

In order to try out the effectiveness of the transmitter previously described and which had been built at Rocky Point, Long Island, engineers with suitable measuring equipment were sent to England to begin a statistical study of signal strength, noise strength and related matters. A program of weekly tests, wherein signals were sent from Rocky Point each hour of the twenty-four hours of one day each week, was inaugurated. The one-way telephone circuit thus provided was used as a sample whereby the variation to which radio telephone signals are subject could be explored, cataloged and studied over an extended period of time so that estimates could be made of the improvements which would be necessary before anything in the way of reliable communication could be established.

Statistical Study of Ether Path

This study of transmission, begun prior to 1923, has been continuously carried on and a large volume of statistical information has been collected. There are two kinds of variation with which to contend. First, the strength of signal changes radically with the time of day, being stronger at night. Second, the amount of radio noise present is usually less in the morning and increases toward the evening and ewll into the night. It is not, however, the absolute strength of the signal which is controlling, as heretofore stated, but the extent to which it dominates the noise. Therefore the ratio between the signal and the noise is the factor which indicates the degree of satisfaction with which communication can be carried on. While signal transmission does not change widely between summer and winter, the amount of noise present in the summer time is usually very much greater than that in the winter time, so that the difficulties of communication in the summer are greatly increased.

It soon became apparent that the amount of increase in the signal-to-noise ratio necessary to put conversation on anything like a practical basis would be so great that to hope to get it by increasing the power at the transmitting end was quite out of the question. Thus improvement had to be looked for at the receiving end, and the problem became one, not of increasing the signal strength, but one of decreasing the amount of noise which was allowed to get in the receiving set along with the signal.

Economic Aspects of Transmitter and Receiver

The economics of the situation therefore were as follows. A powerful and efficient 200-kilowatt transmitting plant, worth nearly $1,000,000, was in operation. The cost of the receiving systems, in general, was insignificant in comparison. Until the audion or vacuum tube appeared, the distance to which radio signals could be sent was limited by the difficulty of getting the signals loud enough to be easily audible in a telephone receiver. There being no ability to amplify, it was necessary in long distance point-to-point communication to build large and expensive receiving antenna to intercept as much signal energy as possible. The search for sensitive detectors to convert this energy efficiently into telephonic currents was one of the principal activities of radio investigators. The vacuum tube changed all this by so increasing the sensitivity of reception that even the weakest signals could be amplified to any desired loudness.

Thus the first influence of the vacuum tube, aside from increasing the possible signalling distance as part of the transmitter, was completely to upset the economic balance between transmitting and receiving. A large and expensive antenna for receiving became unnecessary because the signal from the small antenna could be amplified. The receiving antenna became cheaper.

(*Continued on page 220*)

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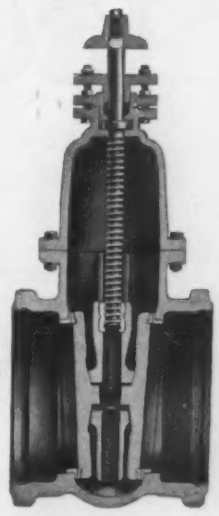

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Transatlantic Radio Telephony

(*Continued from page 218*)

Receiving Problems Given Greater Attention

For many years it had been the dream of inventors to create a device which, attached to a radio receiving antenna, would eliminate static. It would have taken an optimistic dreamer to conceive of cutting down the power of static 20,000 times, but this is relatively just what is now being done as compared with earlier receiving apparatus of less than a decade ago. This improvement came about through the application of two simple but important principles. The first of these is directional receiving. The available agency best adapted to accomplish this was found to be the wave antenna, a form of antenna developed by the engineers of the Radio Corporation of America. It consists of an open wire line three or four miles long which is grounded at both ends with the characteristic impedance of the wire-to-ground circuit. This is substantially an aperiodic system, there being no reflections at the terminal. The radio waves which approach this line from the side produce relatively very small currents in the grounding wires at the terminals. Waves which approached longitudinally build up currents in the line wire as they proceed along it and cause relatively large currents in the grounding wire at the receiving end. By building such a line so that it points toward the transmitting station and attaching the receiving set at the end most distant from the transmitter, it is possible to obtain a considerable degree of directivity. Further development with this simple basic antenna system is obtained by attaching to it various balancing arrangements, or by combining several antennas together it is possible still further to improve the directional characteristics. Such arrangements result in the substantial reduction of static coming in from all except one general direction. Measurements taken over a considerable period of time show that signal-to-noise ratio on a good system of combined wave antennas is about 20 times as great as that on a simple loop antenna. This was very gratifying, since it meant by use of the wave antenna the transmission would be improved just as much as if the transmitting station power had been multiplied by the square of 20 or 400 times. The second principle is the choosing of the best location for the receiving system. Careful measurements disclosed that in Maine, not only was the severity of static less than in New York, but most of it came from the southwest, whereas signals from England come from the northeast. This provides a most favorable condition for realizing the advantages of directive receiving. It was found that in Maine the signal-to-noise ratio was, at least during important hours of the day, something like six or eight times that which was obtained on Long Island. In other words, the improvement was as great as can be obtained by multiplying the power of the English transmitting station some 50 times. These two improvements, representing respectively the equivalent of 400 and 50 times in power increase, multiplied together, account for the 20,000 times improvement which is obtained in the receiver now operating at Houlton, Me. Since the transmitter in England has a power of about 200 kilowatts, it may be said that this unobtrusive little receiving plant in Maine is as fruitful in results as a gigantic transmitting station of 20,000 times 200 or 4,000,000 kilowatts power. It is a veritable radio David, more potent than any Goliath of transmitting station which it would be feasible to construct.

(*Continued on page 222*)

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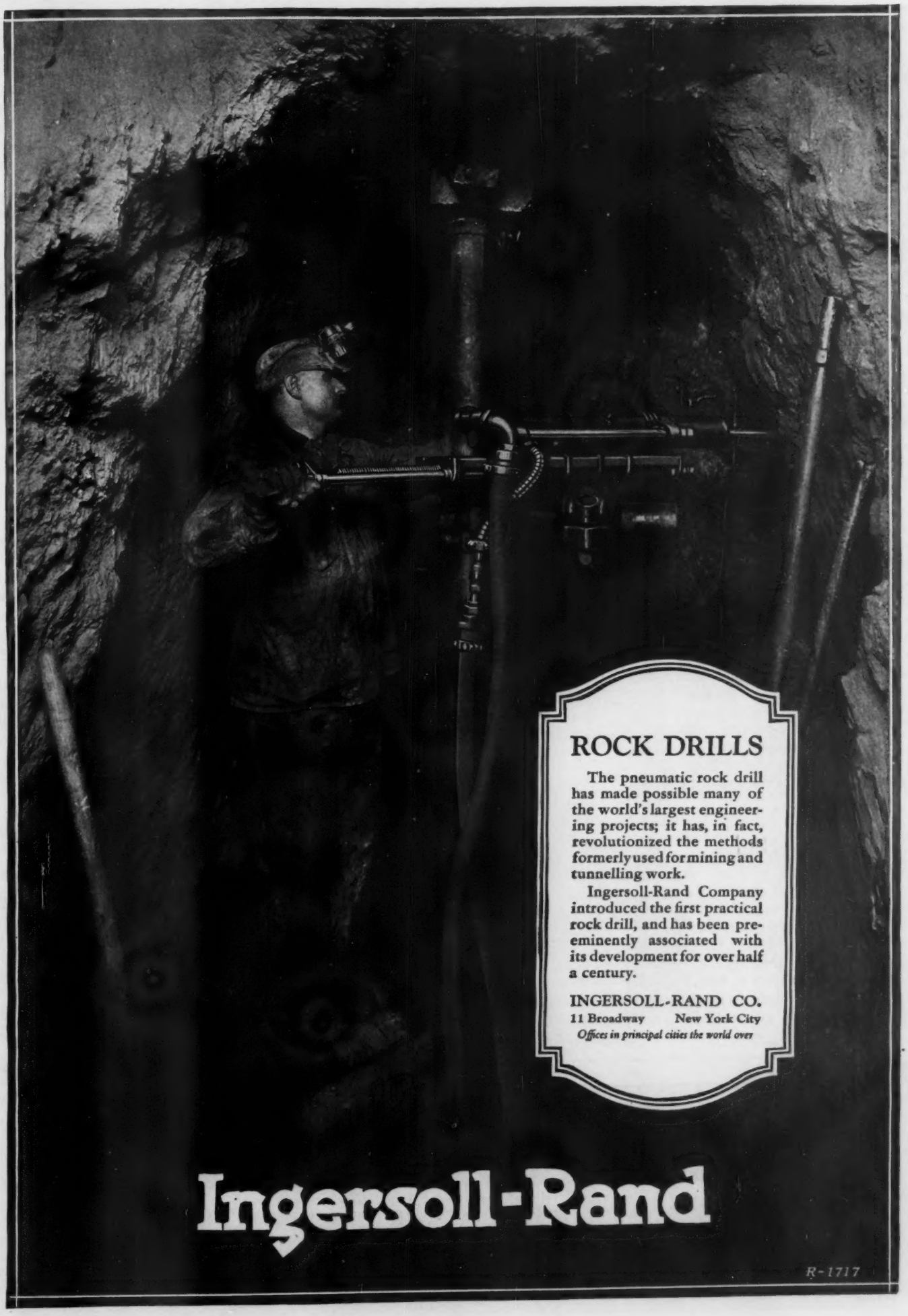
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Radio Telephony

(*Continued from page 220*)

Over-all Effectiveness of Present System

With the advantages of the knowledge of quantitative measurement in the receiving system resulting in a gain of 20,000, there is to be combined the gain of the single sideband suppressed carrier system which is not less than three, thus making the effectiveness of the 200-kilowatt power station more than 12,000,000 kilowatts.

These advances in the radio telephone receiving and transmitting art make the difference between giving a demonstration under favorable conditions and carrying on a daily commercial service; they emphasize the contrast between casual and qualitative experimentation and the operation of a reliable and economic system as visualized by the engineer.

Further improvement in long wave transatlantic radio transmission will be increasingly difficult to get. Possibly it will never be feasible to obtain sufficient further improvement of the present type of system to insure that the circuit will operate reliably through the heavy barrage of static which Nature lays down on many summer days, but the advances now in actual use have already permitted a degree of reliability far greater than could have been realized only a few years ago. For the past few years development work has gone forward in the field of short wave transatlantic transmission. At the present time a complete short wave two-way channel is in operation. Short wave systems give hope of further economies in first cost and in cost of operation.

Whatever may appear to be the best method of supplying telephone communication between the Old and New World, one thing is sure, that that method will be the result of the engineer's ability to control and test the performance of his system as an electrical system, apart from the fact that it is a voice communication system. Ingenuity and invention will, as in the past, play an important role, but the ability to measure will be the keystone of progress.

Ice Engineering

(*Continued from page 203*)

that water may exist in an active or passive state so far as ice is concerned. Under certain conditions of treatment the ice molecules in solution in the water may be destroyed before they precipitate out into the solid form to give trouble as ice. The most useful agent in the destruction of these ice particles in solution is the light from the sun. It is not the heat from the sun's rays which destroys the ice so much as the light. The heat rays from the sun cannot penetrate more than a very small fraction of an inch into the water, whereas the light rays are capable of penetrating for great depth. The energy in the trail of the light ray as it passes through the water is sufficiently great to inhibit the ice forming power of the water and to destroy the ice particles at their inception.

It is unnecessary to point out that none of these methods involve the melting of large masses of ice artificially. What is attempted is to assist the removal of the ice by the conservation of the sun's heat, by breaking up the ice so that the natural flow of rivers will carry it away, and to increase the surface of ice exposed to the corroding action of water, air, and sun; and in other ways to hasten the natural disintegration and disappearance of ice.

The adoption of a particular method for a particular problem depends on the nature of the results desired, on the relative economy of the method, and the judgment of the ice engineer.

Useful information in this connection is obtained from a general survey of the section to be treated, a study of the existing weather and ice conditions and a comparison with previous records where these exist, the determination of the depth and nature of the ice and the flow of water (if any) in the region under consideration, and the lines and points of weakness in the ice mass.

The subject of ice engineering embraces so wide a field and so many different types of problems in which different methods are applicable that it is impossible to give any fixed details in a paper of this kind.

It was in 1896, on the St. Lawrence River, just opposite Montreal, that the first beginnings of this work on ice engineering were made. This study consisted in finding out the relationship between the temperature of the water and the formation of ice in the river.

In order to carry on this work the most delicate electrical thermometer that had ever been constructed was employed. This thermometer gave differences of temperature to a tenthousandth degree. This is necessary because it only requires one one-thousandth (1/1000) of a degree in temperature to determine whether or not ice will form.

During the ice forming period the water is a colloidal solution of ice and it requires the minutest drop of temperature below the freezing point for these particles to coagulate and to agglomerate and form a sticky mass distributed throughout the water. This ice is known as frazil.

The formation of this frazil results in the whole mass of the flowing water becoming almost like a fixed jelly. The particles of frazil ice are carried by the current and are swept under the surface ice in quiet parts of the river where they adhere to the underside and grow down towards the bottom of the river in a great spongy mass.

On the rocks in the bottom of the river outside the shadow of the surface ice the water deposits this ice in the form of tubercular growths. This ice is known as anchor ice and is formed almost entirely at night under a clear sky. When the sun rises in the morning, these masses are liberated from the bottom under the influence of the sunlight and float to the surface and are swept by the water into the masses of frazil ice, thus making them larger.

Thus the whole length of a river will gradually become clogged with ice, the thickness of which may be increased by accumulations of snow. The water, being unable to flow in its natural channel, is forced to find new outlets through the surrounding country by overflowing its banks.

(*Continued on page 224*)

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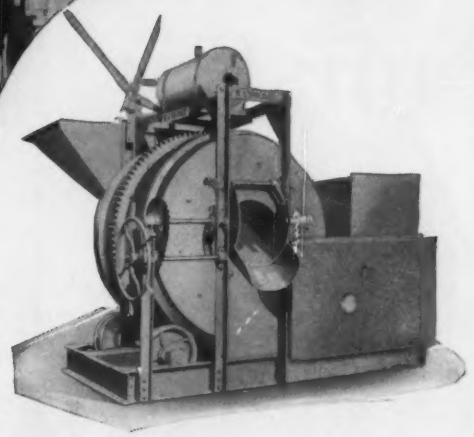

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Ice Engineering

(*Continued from page 222*)

Anchor ice occurs in great masses on rock surfaces in shallow rapids on the up-stream side of the rocks. It forms on the spillways of power houses and acts as a dam to prevent the normal flow of the water.

In the winter time many large rocks and bodies are brought up from the body of the river encased in a great thickness of ice. When this happens these great solid masses of floating ice become dangerous to light shipping.

For the disintegration of these great masses of frazil and anchor ice there is nothing can equal the effectiveness of the thermit treatment. The thermit is placed in a metal container in the center of which is the ignition powder with a lighting fuse or an electric igniter with attached wires. The container is just strong enough to stand the heat until the whole mass of thermit is ignited. The molten iron accumulated at the bottom of the container melts its way through and the molten metal is thrown into sudden contact with the ice. The force of the explosion scatters the molten metal into the ice in the form of small particles resembling the bullets from a gatling gun. In this way the heat is distributed throughout a fairly wide area.

In many instances the thermit treatment would probably not be the most economical and most efficient to use. For the prevention of surface ice or the opening up of a channel through surface ice, calcium chloride or calcium carbide correctly employed would probably be more efficient. Long channels of fairly still water which freeze over quickly during periods of frost form very thin skin ice which is very destructive to ordinary canal craft. Preventive methods should be used in such instances when periods of frost threaten. The most efficient preventive methods are those which utilize the natural heat of the water. Most of these still channels cool to the freezing point only on the surface, whereas the water a few feet down is usually at a considerably higher temperature. Most canals or still water ways could be kept open if the water were sufficiently mixed. A stirring device would do this but this is not always practicable. A pipe line laid along the bottom of the water way through which compressed air could be forced to the surface would be quite effective. This is now in use to stop surface ice along the face of dams and in pen stocks of many power houses where great thicknesses of ice otherwise form.

Further experiments are being conducted along these lines, but rational ice engineering now has a scientific basis.

Electric Furnace

(*Continued from page 216*)

the electric furnace is calcium carbide. This product is required for the production of acetylene gas and is made in an open-top furnace, similar to the ferro-alloy furnaces. Lime and carbon are smelted together to give the calcium carbide by the following assumed reaction:

$$CaO+3C=CaC_2+CO$$

The foregoing, while not attempting to describe in detail the various electric furnaces in use, or their numerous uses, nevertheless gives a general idea of the manner in which the electric furnace compares with other processes in the preparation of various products.

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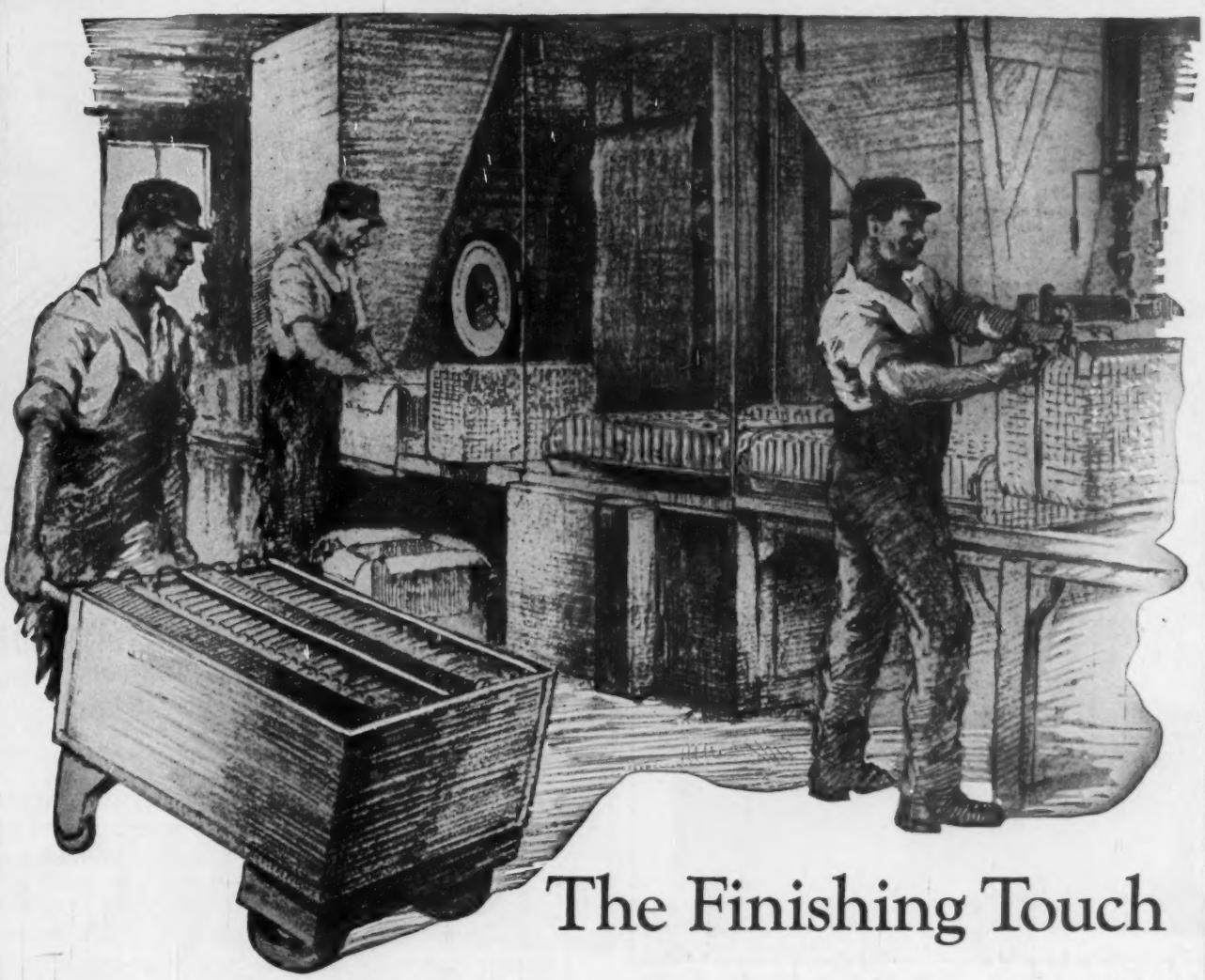

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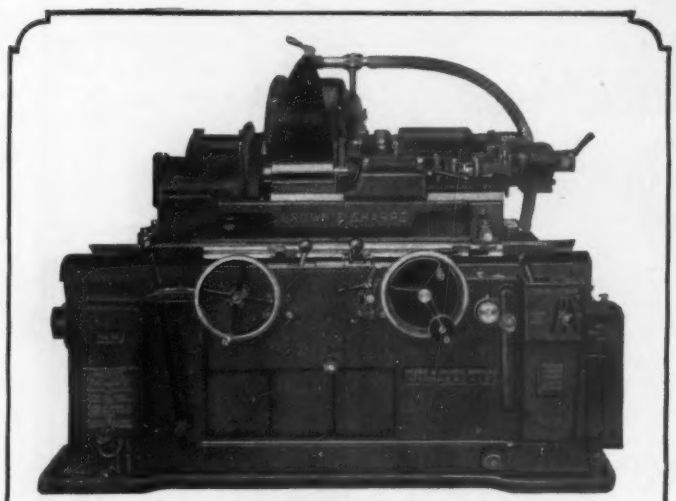

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YOU CAN DO IT BETTER WITH GAS

Education and the Choice of a Profession

(*Continued from page 197*)

construction success was on the way. He was a candy manufacturer! The first day's sales amounted to $2.15. He turned milk and chocolate into fudge, fudge into dollars, and dollars into more milk and chocolate. His sales for the first month were $103.45. Five years later his company was doing a business of over $530,000 a year.

This boy started business without any capital, with over $600 in debts for his law school education, and with no business experience. But his business succeeded almost immediately and in a big way because at last he had found the thing he wanted to do.

Another example of this change from following the lines of specialized education is to be found in the two civilians who have graduated from the course in the theory of warship design given for the Naval Constructors at the Massachusetts Institute of Technology. One is now selling insurance, the other has entered the ministry, thus turning completely from a field of potential warfare to respectively offering protection against the risks of fire here, and hereafter.

This experimental determination of occupation is no unusual thing, but is it necessary? Is it desirable? It would seem to indicate something inherently wrong in our method of choice. Misfits are usually the result of one of three things: ignorance of self, ignorance of what the work involved requires, or lack of purpose, ambition, and courage.

Suppose that instead of trying to choose between the law and business, between chemistry and architecture, between geology and aeronautical engineering, a young man predicated his choice of a career upon his ability as an executive or a salesman, as a research scholar or one who carries out the plans made by other people. Certainly there is little if any difference between the fundamental abilities required by the man who superintends the construction of dams and the man who erects power plants, yet how many boys have agonized over whether to study civil or mechanical engineering.

The executive goes successfully from one type of enterprise to an entirely different undertaking with little loss of efficiency. For instance Matthew C. Brush, '01, left the presidency of the Boston Elevated Railroad to take charge of the shipbuilding program at Hog Island. That he, at the beginning, scarcely knew the difference between "the blunt end and the sharp end" of a vessel in no way interfered with his fitness for the position. Did he, as an undergraduate, struggle to decide whether to take Course I or Course XIII? He did not. He decided to study how to handle men. He knew that he wanted to be an executive.

Turning from the executive to the research type of mind we find such men as Edwin B. Wilson, once professor of mathematics, then head of the Physics Department at Technology and now professor of vital statistics at the Harvard Medical School. One could keep on giving examples almost endlessly.

Most boys select a career, not because they know that they have a genuine liking for the type of work involved and can contribute original ideas to its development, but because they know someone who has made either fame or fortune in the particular line of endeavor. Boys do not ask themselves, "Have I the qualifications for' doing the things an executive is called upon to do?" They usually court disaster by ignoring this question entirely and dreaming a beautiful day

(*Continued on page 230*)

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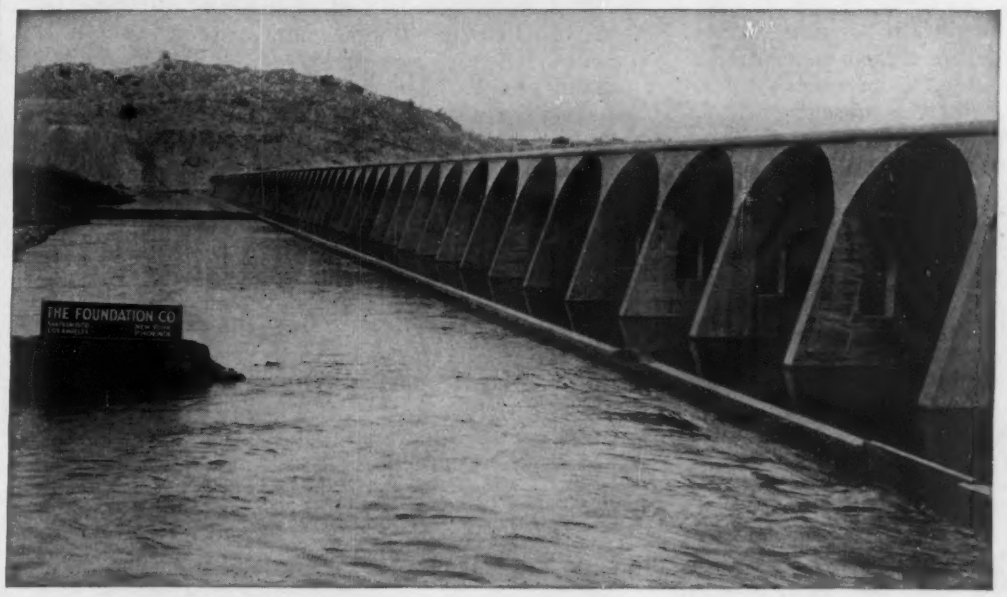
DAMS.



Man Taught By Nature

GILLESPIE DAM, GILA BEND, ARIZONA, CONSTRUCTED BY THE FOUNDATION COMPANY

INSTINCT in the beaver taught it to back up the streams with brush and mud dams, to store the water in still ponds in which to live and preserve its food. Reason and experience of man has taught him to dam the streams for the storage of water for power, for irrigation, and for other purposes.

In the present day the use of water for hydro-electric development has directed the interest of industry toward harnessing all available streams where power can be distributed to industrial centers. The desire of the farmer to reclaim the arid waste spaces and make them fertile has brought about the storage of water and its directed distribution to these spaces. Flood control by the storage of the waters, to prevent destruction of life and property, is receiving constantly increasing attention. These purposes are being accomplished by the construction of stable dams securely founded.

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BUILDERS OF SUPERSTRUCTURES AS WELL AS SUBSTRUCTURES

Education and the Choice of a Profession

(*Continued from page 228*)

dream about themselves; their name on the door, stenographers and office boys leaping to attention when they press a button, boards of directors being visibly impressed.

It is even more important to know *why* you think you would like a certain type of work, than it is to know that you think you would prefer it. Know yourself. Know your fellow men so that you can interpret your own emotions and mental processes; so that you can understand the behavior of other people. What is fundamental in your own make-up, and what is only a surface reaction due to prejudice, a preconceived idea, or a false conception of what things mean and are? At least fifty per cent of the present freshman class will find themselves ten years from now in an entirely different picture from that which they now fondly visualize. Why? Because they do not yet know the truth about themselves. "Know the truth, and the truth shall make you free."

The difference between thinking that you know what you want, and actually wanting it should never be lost sight of. There is a great deal of difference between saying "I want to do this," and saying "I have already successfully done this." How do you know that you want to be a chemist until you have tried it? The young man who works during his summer vacations does himself a double service, clarifying his own preferences and abilities, and furnishing tangible proof of his fitness (or unfitness) to some later employer. All you can hope to do in life is to develop the abilities with which you were born. No amount of work or desire can make a musician of a man who has no conception of pitch and rhythm. It simply isn't in him. The first and most difficult task is to positively discover where your aptitude lies. The rest is easy. Develop it.

There are, to be sure, a very few fortunate lads who never seem to have to make a conscious choice of a profession at all. The Hon. Edward P. Warner, '17, Assistant Secretary of the Navy for Aviation, says that except for the first few days following a serious accident and a subsequent operation, he has read, written, or studied something about airplanes every day of his life since he was twelve years old. No wonder he occupied a seat with the mighty at the age of thirty.

The aim of education should be to help a man to find himself, to understand himself, and to make the most out of himself. This is far more than the mere conveying of facts and formulae. It is the developing of intelligence. Intelligence is the ability to look at a situation, see what is needed, and frame a proper line of action. Information is knowing what somebody else did.

The two big questions which a young man should ask himself in choosing a career are "What can I do best?" and "What are the things I cannot do?" If you want to be a salesman, it makes little real difference whether you study mechanical engineering and sell lubricating oil, or study chemistry and sell soap. In either case you know that you lack the ability to become a successful research scholar.

If you are always asking yourself why is this so, how does that work, what does that mean; always asking, and what is more important, then trying to find the answer, you will probably be equally happy and successful chasing microbes through milk or searching for a new formula to express fluid pressures on flat plates.

Many a boy has been inadvisedly guided into trying to become an in-

(*Continued on page 232*)

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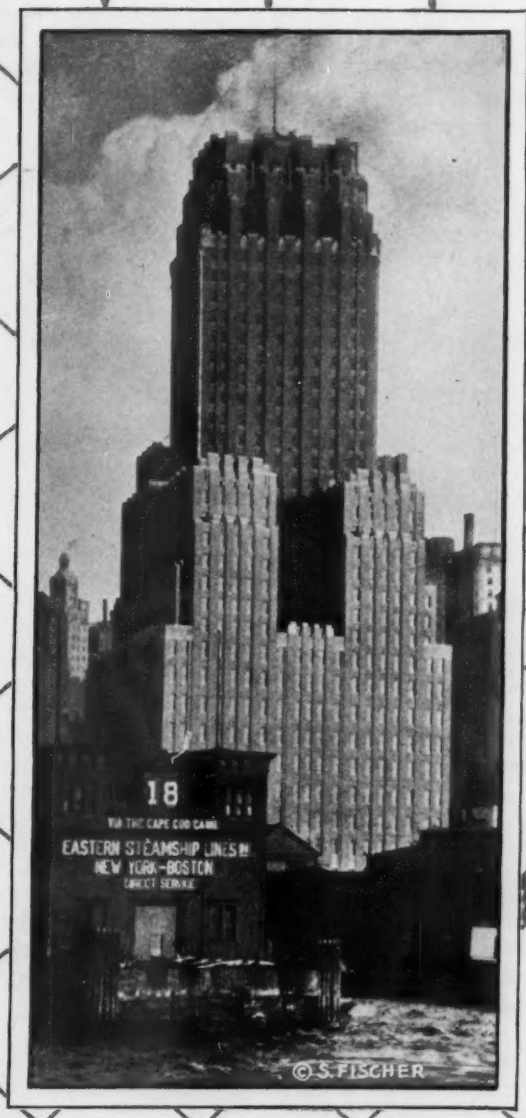

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CHICAGO ST. LOUIS

Education and the Choice of a Profession

(*Continued from page 230*)

ventor just because he "made the back doorbell work when the electrician from the Brightspark Company didn't even find that the jar needed sal ammoniac." But the chap who was original enough to have devised a rat trap from two elastics, the family Bible, and his grandmother's false teeth — no, his parents could not read the handwriting on the wall. They branded him as impudent and irreverent with never a thought for his inventive genius.

Years ago the great engineering problem was to find some means of obtaining strength over large spans. Today, it is to design foundations strong enough to hold the enormous superstructures which we are erecting. Once it was held by some that the problem of education is that of spanning a vast quantity of information. Today we are coming more truly to realize that education is the building of an adequate foundation for the superstructure of a successful life; a life which is a gradual progression toward a worthy ideal which represents the highest of which one is capable. Education, then, is merely self-discovery. It is learning our powers and our limitations. It is realizing what a wonderful world we live in. It is a rigorous discipline of the powers of reasoning and of observation. It is learning that there is no abiding happiness except the joy of worth while accomplishment; that there is no accomplishment except in work for which one is fitted, work to which one can contribute new ideas, work which is a life purpose, not just a job.

In the nineteenth century men learned to understand natural law. In the twentieth men will learn to understand themselves. Some day it will be as easy to select from a given group of boys those who should become executives, lawyers, teachers, or salesmen, as it now is to separate a pile of castings into gray iron, alloy steel, and phosphor bronze. Then the choice of a profession will be as simple and as sure as the choice of the proper material for fence posts. Until then, like my neighbor who is making a fortune in the candy business, we must struggle with the limited means at our disposal to find out what we want to do and then to do it. Self-revelation followed by self-expression and by self-realization.

An analysis of the major qualities which would indicate aptitude for a given profession should not be particularly difficult. For example, the architect must possess an appreciation of form, color, and proportion. He is usually a man of fine physical texture, a lover of beauty who knows how to obtain the most artistic effect from his raw material. He has originality, patience with details, and a keen observation ever alert for new ideas.

The construction engineer must possess a more robust physique, for he is a doer rather than a dreamer. "Get it done" is his motto. Method, aggressiveness, mechanical sense, dependability, and the God-given talent of being able to handle men are all written large on his character.

Not so the pure scientific scholar. The last thing he wants to do is to carry out the ideas of other people. Keen critical faculties and absolute independence of thought give to him an ability to explore new fields of knowledge. He weighs results analytically, impartially, and without prejudice. Endless patience endows him with the capacity for examining the most minute detail. He has imagination; not the creative imagery of the architect, nor the visualizing processes of the construction engineer, but a power of mind by which to decompose conceptions and to recombine the elements in new ways. He may have the most disagreeable and unattractive of personalities and still stand at the top of his profession, if only he is a great thinker.

The outstanding characteristic of the salesman is his ability to persuade. He understands human nature. He is a convincing talker. He makes people like him. His self-confidence, aggressiveness, persistency, and courage are all necessary, but they are cunningly veiled, at least while dealing with a customer, by his ever present tact. He has a keen commercial sense and plans his sales campaign with as much intelligent use of strategy and tactics as a major general.

The time will come when we can analyze a man quantitatively and qualitatively for the elements of his character, just as today we can analyze a chemical solution. When that happy achievement has been realized the principal cause of misfits in industry will have been removed. Men will no longer be ignorant of their own qualities.

In the vast majority of cases the particular course you studied at the Institute makes little difference. By actual count less than 30 per cent of my Technology classmates are following the exact professional work for which they prepared. The thing of vital importance is that a man find the group to which he belongs, not by the childish method of counting rich man, poor man, beggar man, thief; nor by the mature classification which begins civil, mechanical, mining, etc.; but according to the more fundamental distinctions of thinker, executive, salesman, worker.

To be either happy or worth while, a man must like his work. He must love it as a woman loves her children. But, as was wisely remarked long ago, if you find yourself in a job that you dislike, don't worry; somebody else will soon have it.

A New Locomotive Design has been developed and is being thoroughly tested at the Sacramento shop of the Southern Pacific Railway. The engine is a remodeled Mallet, built to run in the reverse of its normal direction. The position of the cab on the front makes better vision possible and allows a more efficient arrangement of the many gauges and controls with which the engineer manages the 105,340 pounds of traction power.

By using four high pressure cylinders instead of the usual Mallet compound system; by building the boiler in one section and increasing its length; by using a more efficient super-heater; and by incorporating a "booster" on the rear truck of the tender, the designers have added 25 per cent to the traction power, which in turn adds as much to the maximum full load speed.

This engine, after it has been thoroughly tested, will be used, with others like it, for hauling perishable loads over the Rocky Mountains where speed on a continual upgrade is of prime importance.

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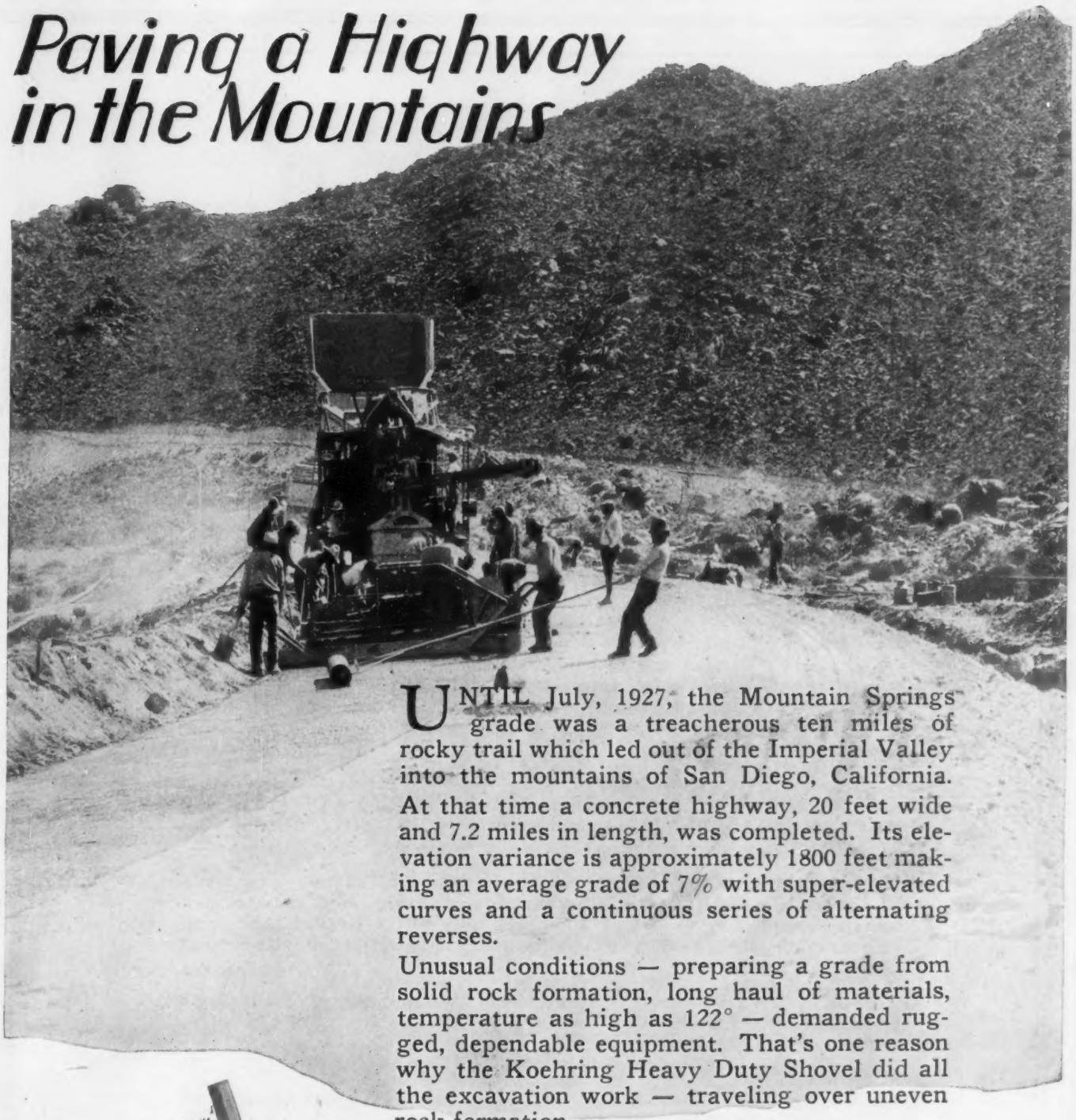
Paving a Highway in the Mountains



UNTIL July, 1927, the Mountain Springs grade was a treacherous ten miles of rocky trail which led out of the Imperial Valley into the mountains of San Diego, California. At that time a concrete highway, 20 feet wide and 7.2 miles in length, was completed. Its elevation variance is approximately 1800 feet making an average grade of 7% with super-elevated curves and a continuous series of alternating reverses.

Unusual conditions — preparing a grade from solid rock formation, long haul of materials, temperature as high as 122° — demanded rugged, dependable equipment. That's one reason why the Koehring Heavy Duty Shovel did all the excavation work — traveling over uneven rock formation.

At the stock pile and batcher bin a Koehring Heavy Duty Crane handled the crushed rock and sand while on the grade a Koehring Heavy Duty Paver mixed the dominant strength concrete, — a complete Koehring-equipped job.

"Concrete — Its Manufacture and Use," a complete treatise and handbook on present methods of preparing and handling portland cement concrete, will be gladly sent on request to engineering students, faculty members and others interested.

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THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers Courses, each of four years' duration, in Civil, Mechanical, Electrical and Aeronautical Engineering; Naval Architecture and Marine Engineering; Mining Engineering and Metallurgy and Geology; Architecture and Architectural Engineering; Chemistry, Chemical Engineering and Electrochemical Engineering; Biology and Public Health and Sanitary and Municipal Engineering; Mathematics, Physics, General Science and General Engineering; and in Engineering Administration. These Courses lead to the degree of Bachelor of Science.

To be admitted to the first year class applicants must have attained the age of seventeen years, and must satisfactorily fulfill entrance requirements in Algebra, Plane and Solid Geometry, Trigonometry, Physics, Chemistry, English, History and French or German and two units of elective subjects. Examinations are required in all subjects except Chemistry, History and the electives, the requirements for which are fulfilled by the presentation of satisfactory certificates. A division of these entrance subjects between different examination periods is permitted.

Entrance examinations are held at the Institute in September. In June applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

Graduates of colleges and scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding to at least one year's work at the Institute, are admitted without examination, to such advanced standing as is warranted by their previous training.

Graduate courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy, Doctor of Science and Doctor of Public Health are also offered. Special Research Laboratories of Physical Chemistry, Organic Chemistry, Applied Chemistry and Science have been established.

Correspondence should be addressed to the Institute of Technology.

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Catalogue: Bulletins of General Information, Summer Session, and Graduate Study and Research; and the Report of the President and the Treasurer.

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CAMBRIDGE A, MASS.

"DIGA"

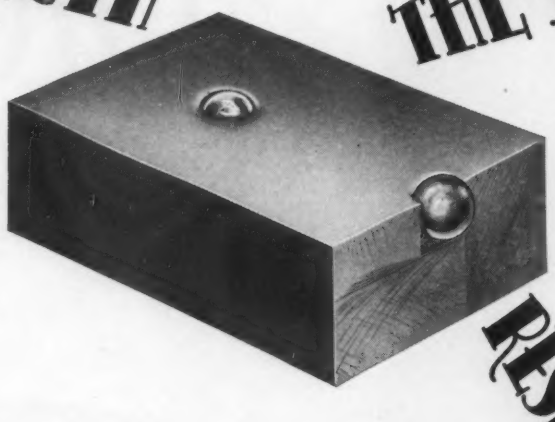
THAT'S the telephone "Hello" in Madrid. In London, it's "Are you there?" But in many foreign countries, Americans find a universal language in the telephone salutations. It's good old "Hello"—a subtle tribute to the fact that the telephone is an American invention.

And so it is with elevator service. Even though they say "Diga" in Spain, the architects of the magnificent new Madrid Telephone Building unhesitatingly said "Otis" because Spain demanded the last word in elevators. You will find in Madrid the same type of Signal Control Elevators that are now installed in those monumental telephone buildings in America, in New York, Cleveland, St. Louis and San Francisco.

OTIS ELEVATOR COMPANY

Offices in All Principal Cities of the World

STRENGTH



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A TRUE SPHERE

is the strongest shape for a given size known to man.

The steel ball in a New Departure Ball Bearing combines accuracy with a strength that is seldom entirely appreciated. 17/32-inch New Departure steel balls were forced into a tough steel block under 108,000 pounds pressure—and they are still good!

Consider this strength combined with an accuracy in sphericity to within .000001 inch (one-millionth of an inch) and you have some conception of the superiority of New Departure Ball Bearings over other anti-friction bearing types.

The next discussion will be on the subject of electric furnace high carbon chrome alloy steel and the part it plays in making New Departure the most enduring bearing for any purpose.

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Where do young college men get in a large industrial organization? Have they opportunity to exercise creative talent? Is individual work recognized?

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PHILADELPHIANS who use the new Broad Street Subway now travel the seven miles from Olney Street to South Street in less than 20 minutes; a trip that formerly took 45 minutes. There is an extra hour of freedom every day for those who use this new route to travel to and from business.

The operating conditions imposed on cars by a rapid transit subway system of this kind are unusually severe and require careful and special design of the electrical equipment. The 150 modern subway cars, 67 feet long, powered by two 210-horsepower Westinghouse motors and controlled by Westinghouse equipment, that operate in this subway are a notable achievement in electrical engineering. Westinghouse takes pride in the fact that it was called on to furnish this equipment.

Big jobs go to big organizations. Westinghouse attracts young men of enterprise and genius because it daily provides opportunities that smaller corporations can seldom offer.

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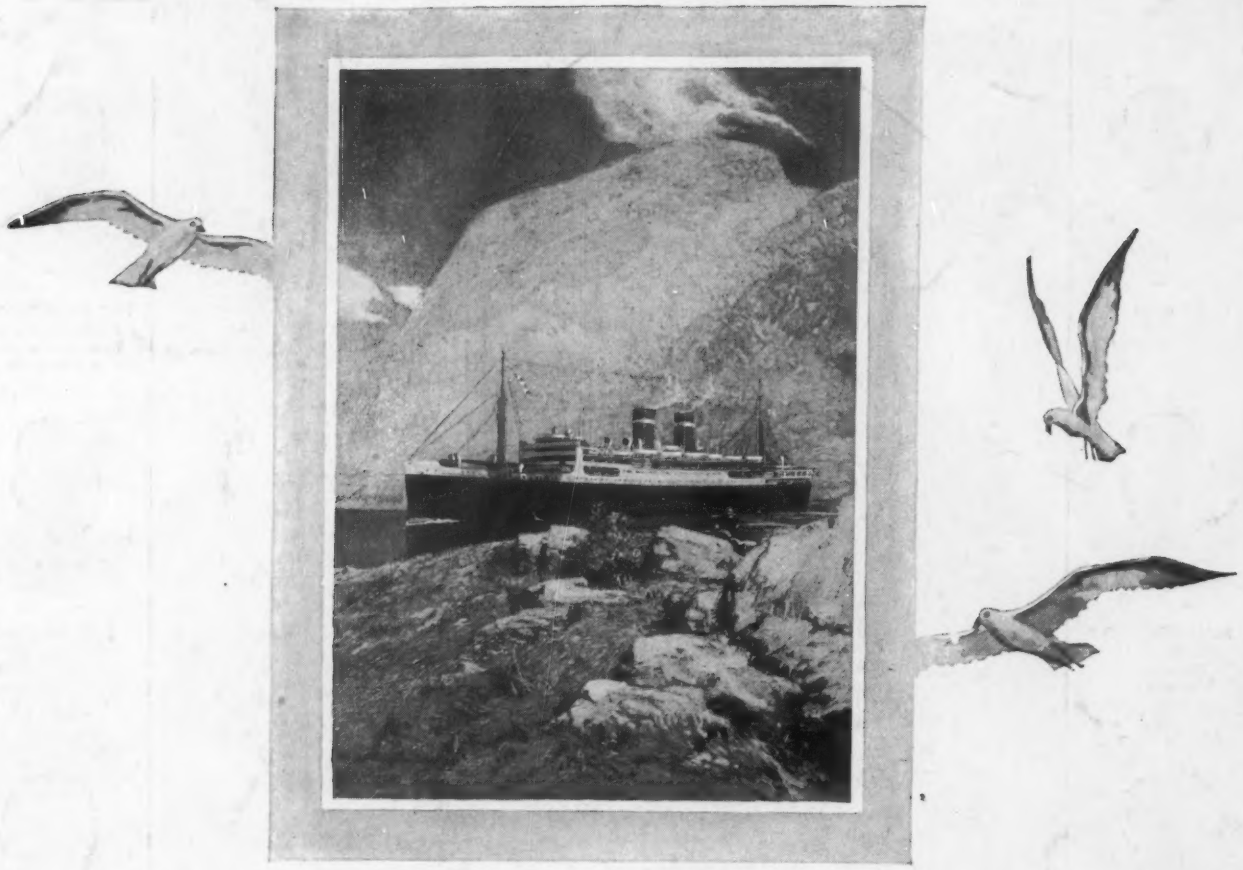
The Broad Street Subway was built by the City of Philadelphia at a cost of more than $100,000,000. The 150 cars that serve this subway have motors, control, switch panels, fans and battery charging equipment designed, built and installed by Westinghouse. The story of some of the conditions facing the engineers on this job, and how they were overcome, may be found in an article in Electrical Railway Journal for June 9, 1928.

Westinghouse



Completely electrified—
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Completely electrified—quiet, vibrationless, luxurious, swift—the S.S. *California,* largest American-built passenger ship, has opened a new era of ocean travel.

Two turbine-generators, each rated at 6600-kw., supplying power to two main propulsion motors, constitute the turbine-electric drive, used for the first time in a large passenger ship. Four turbine-driven 500-kw. d-c. generators supply power for auxiliary equipment which aids in the operation of the ship and adds to the comfort of passengers.

Complete electrification makes the *California* an engineering marvel and a commercial success; it is booked far in advance, a sister ship has just been launched, and another is under construction.

College-trained men of the General Electric Company, which engineered the electric power installation on these luxurious passenger ships, have thus played a significant part in the opening of a new era of ocean travel.

This monogram is found on great motors that drive the *California,* and on a multitude of electric appliances which contribute to the comfort of her passengers. It is an emblem of skilled engineering and high manufacturing quality.

6-28DH

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